POWER

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Let's Go to Work

BUSINESS conditions always affect the engineer. If he is one who has charge of the operation and maintenance of a plant, the dull seasons, if not too long, are his busy ones. He finds opportunity to make much-needed repairs. If he is a consulting engineer general depressions bring slack periods in his own business. So perhaps some impressions on the business outlook in this trying period through which we are passing will bring a better appreciation of conditions and assist in the formulation of plans which may be in contemplation, for nearly everyone is planning in accordance with what he sees ahead for business.

America is not alone at this time in the throes of adjustment following a great war. The world over it is the same. People are but now, two years after the signing of the Armistice, sobering from the intoxication of that war. The purse strings have been pulled taut with the suddenness of a cable lifting a bucket from a coal barge.

This is the period of I-won't-buy. It is the morning after a riotously extravagant night.

When people stop buying for long, manufacturing must stop. There is a limit to the burden that all industries can stand. Orders must come in above some minimum volume to support the men and machines producing the commodities for sale. In many if not most lines, that limit is reached. The burden that is fixed, the idle, or underworked machines, cannot be lightened. The labor charge can—men are therefore laid off. Employers believing their men overpaid, find it a good time to apply wage reduction on those they can keep working. The labor market is liquidated.

In many lines there are stocks of completed commodities, not large stocks, but some at least. In others there is a serious shortage. These stocks were made from high-priced materials with high-priced labor. Yet universally there is refusal to buy at present prices, which are, by and large, lower than they have been for a few years.

Commerce is crippled with buyers' inertia. There is cold and congestion in the pocketbook. The Stock Market shivers off several points.

How can it be sweated out? That is what every business man is asking. There are many qualified diagnosticians, but few Battle Creeks to effect a cure.

The incongruity of it all is that when the shelves of the world are bare we sit looking at them and weeping instead of sweating and working.

Now we are in this mess and we must get out of it. None of us believes we can get what we want without working for it. We are not hoboes.

The situation must be paid for by someone, though he who pays may not have created it any more than one creates the death of a man whose funeral expenses he pays.

Somebody has got to take the loss on goods, made from high-price materials, and somebody else has got to take a loss on similar raw materials to bring prices low enough to get people buying what they need. The loss will probably be no greater than the excess profit made when the low-cost goods and materials on hand before the rise were sold at inflated prices; so many will break even.

This inertia on the part of the buyer must be overcome. He won't overcome it. Not on his three-year overcoat he won't! And you cannot hunger-strike him into doing so because you are he.

Some manufactories are in far less favorable circumstances than others to meet this condition. They are those who delayed in increasing their prices, but who had and have good, honest reasons for doing so. Most of them are entitled to ride in the front coach, but it looks as though they have got to go to the funeral.

Let's go! Let us bury this corpse, weep as much as we have to, get back to the house, put on our jeans and go to work.

Let's go to work!

Salient Features of Large Gas-Fired Generating Station

Gas-Burning Central Station of 23,500-Kva. Capacity—Gas Piped Thirty Miles—Circulating-Water Cooling Tower to Handle Fifty Thousand Gallons Per Minute —Two Different Steam Pressures and Superheats Used in Plants

By R. C. DENNY
Operating engineer, San Joaquin Light and Power Company

WITH the installation of a new 12,500-kva. turbo unit the Bakersfield steam plant (Fig. 1) of the San Joaquin Light and Power Corporation occupies a position unique in the annals of steam engineering as a natural-gas burning plant. The equipment now includes three 60-cycle, 2,300-volt, 1,800-r.p.m. turbo-alternators of 12,500-kva., 6,000-kva. and 5,000-kva. capacity respectively. Excitation is provided from a common bus at 125 volts, the exciter units being a 100-kw. motor-generator set, a 75-kw. 3,600-r.p.m. turbine set and a new 150-kw. 7,200- to 900-r.p.m. reduction-gear turbine set. Approximately 15,000,000 cu.ft. of gas per day are the fuel requirements. This enormous quantity of gas is piped in from two different fields through six-inch pipe lines a distance of thirty miles. Reaching the plant and passing through reducing valves, the gas is measured by orifice meters and passes on to the furnaces. The gas burners are made up of nipples of ordinary half-inch pipe, tapped out on each side of a two-inch main pipe (Fig. 6) every six inches along its length. These nipples are capped and near the end are drilled out $\frac{1}{8}$ in. on the top side. Above these holes and

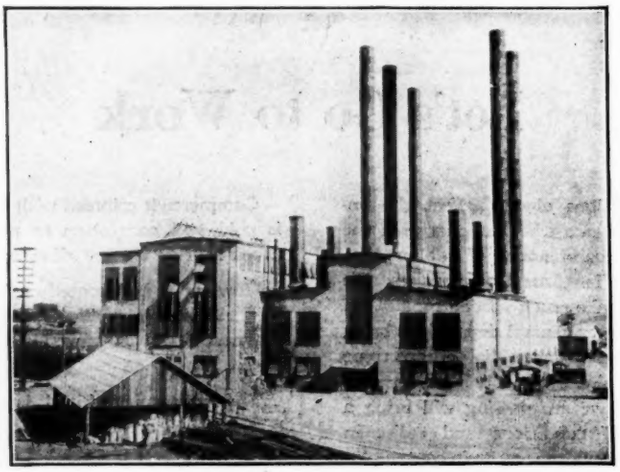
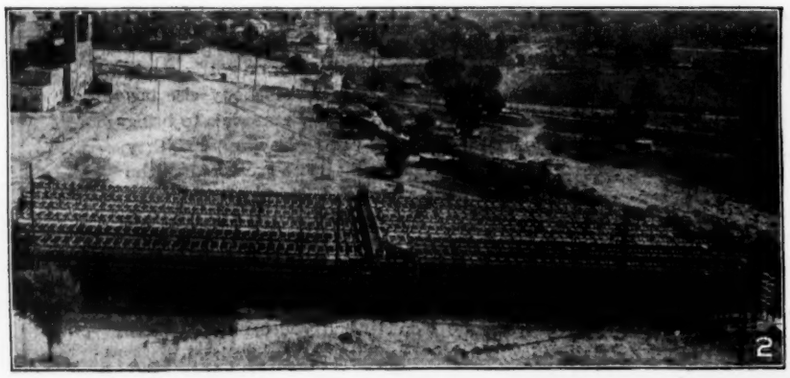
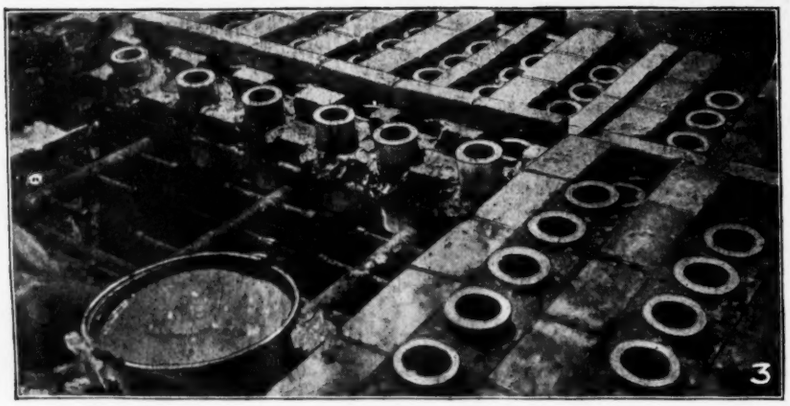
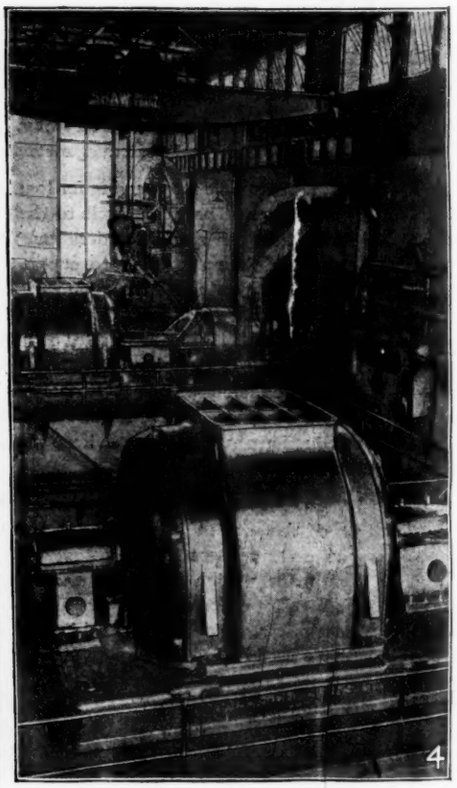


FIG. 1. EXTERIOR VIEW OF BAKERSFIELD PLANT







FIGS. 2 TO 4. VIEWS OF VARIOUS PARTS OF STEAM PLANT
Fig. 2—Condenser circulating-water cooling tower. Fig. 3—How gas burners are arranged. Fig. 4—Interior of generating station

centered with them are placed fireclay tiles cemented in with asbestos cement. This constitutes a burner, of which there are six banks of thirty-four each under each boiler. (See construction, Fig. 3.)

Originally, fuel oil was burned, and the oil piping and burners were left in place ready for any emergency. There is at the plant an oil-storage reservoir having a capacity of 23,000 bbl., sufficient to tide over gas-line troubles for a week.

The two smaller turbo units are operated at 200 lb. pressure and 100 deg. superheat from eight 603-hp. water-tube boilers, while the large unit is operated from ten 822-hp. boilers of the same type at 250 lb. pressure and 125 deg. superheat. Two of the 822-hp. boilers are equipped with auxiliary relief valves so that they can be cut over to work with the 603-hp. boilers at 200 lb. pressure.

Natural draft is used, and the stacks are made of riveted steel 90 in. in diameter. There are, in all, nine stacks, five of them 165 ft. high, all cross-guyed to one another and to reinforced-concrete anchors.

A large cooling tower (Fig. 2) occupies one end of the property. This tower is built entirely of wood, is 24 ft. high and stands in a cemented reservoir 134 x 346 ft. surrounded by a 3½-ft. concrete wall. Fifty thousand gallons of water can be pumped over this tower per minute and cooled 25 deg. F.

Graphic meters are used throughout the plant, and a laboratory adjacent to the main building is proving a useful adjunct. Here are installed a calorimeter and a density balance. Several tests are made daily to determine the specific gravity of the gas and its B.t.u. values. This makes it possible to check each day's run for over-all plant efficiency. Tests are also made on the

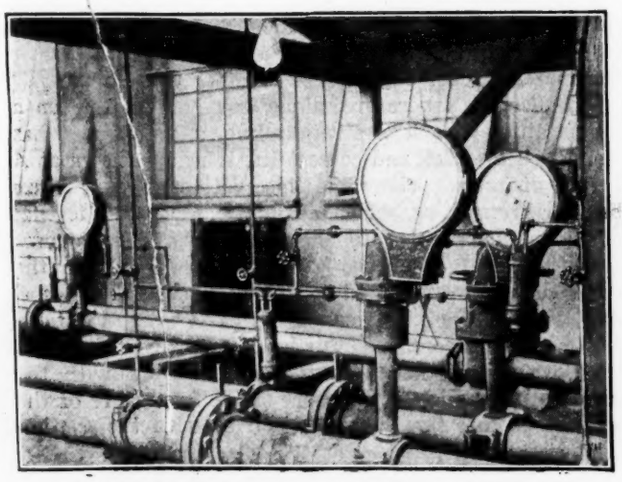


FIG. 5. ORIFICE METERS ON GAS LINES

boiler-feed water so that proper treatment may be applied. Bailey boiler meters are used in connection with CO_2 recorders, Orsat apparatus and draft gages. Steam-flow meters are used on each of the main turbo-units to indicate and integrate the steam consumption. One man at the plant has all these meters under his supervision as well as the testing laboratory. He instructs the firemen and engineers so that all strive for efficiency in their methods.

Since the new unit has been in operation and the entire plant running at nearly 100 per cent capacity factor a great increase in efficiency has resulted. Especially since using gas only, the efficiency has attained the figure of 38 kw.-hr. per thousand feet of gas, or an increase expressed in equivalent oil of 55 kw.-hr. per barrel more than when burning both gas and oil and operating the two smaller units at 97 per cent capacity factor.

A weekly record is kept at the plant of all expenses incidental to operation, and from this, along with the labor, fuel and fixed charges, a kilowatt-hour cost slip is made up in the general superintendent's office. The segregations on this record are essentially for the information of the operating department. Similar records are kept on all generating plants of the system.

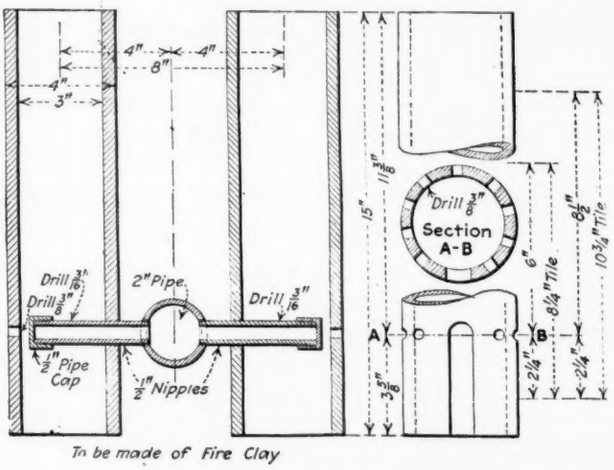


FIG. 6. DETAILS OF GAS BURNER

The new unit, with all its auxiliaries, was installed and put in service on schedule time despite transportation difficulties coming on the system in time for the peak period of the year. Some of the difficulties encountered which may be of interest are as follows:

The chief transportation difficulty at the time was the general strike of railway trainmen and the inability to get material in motion, due to strike and the freight embargo. The condenser for the unit, after being loaded on the car at Carteret, N. J., stood ten days at the factory and was finally shipped about May 12, after an appeal to the Interstate Commerce Commission. It was then lost track of for several weeks and after much tracing was located at Streeter, Ill., where the car had broken down. After some delay the apparatus was transferred to another car and again started on its westward journey about June 16. Some anxiety was felt about getting it through the tunnels in the Tehachapi Mountains except perhaps as a special, but this fear proved to be groundless as the car went through all right as a regular freight.

Arriving at Bakersfield on June 25, the car was shunted to the steam plant, where another difficulty, not anticipated, was presented. The track into the steam plant approached the door on a slight grade and apparently for this reason there was not sufficient headroom to get through the door, the shell only just wedging under. It was considered easier to lower the track to a level than to unload the equipment, so the track was lowered, but still there was not enough clearance. The top of the door was then torn out, and even then it was necessary to spring an I-beam that proved to be in the way. Once inside the building the condenser was put together and ready for try-out in five and one-half days, the men working in shifts night and day. This

record was due largely to working three men in the condenser, one in each section, to guide the tubes into place.

Some of the other equipment was delayed until the last, such as a circulating pump and a large valve or two, but nothing of such consequence as the condenser. One could naturally expect transportation difficulties during a strike, and while there were inconveniences, the job was put through in good time by keeping at it day and night. The work was under the supervision of the company's general superintendent, E. A. Quinn, whose able management and tireless efforts were responsible in a large measure for the early completion of the work. July 17 was the date that the new unit was put into service for the first time to carry load, and its operation since has been very satisfactory.

Mean Effective Pressure of Ammonia Compressor

By D. H. Stokes

The mean effective pressure of any gas compressor is found by the formula,

$$M.E.P. = \frac{K}{K-1} P_1 \left[\left(\frac{P_2}{P_1} \right)^{\frac{K-1}{K}} - {}^{\frac{K-1}{K}}1 \right] \qquad (1)$$

in which K is the ratio of the two specific heats of the gas, P_1 is the suction pressure, and P_2 is the delivery pressure.

When the indicated horsepower of a compressor is required, it is necessary first to obtain the mean effective pressure. This may be done by drawing a diagram with abscissas or vertical lines every tenth of the stroke, and calculating the pressure at those points by the formula,

$$Pressure\ required = \frac{P_1 V_1^{\,k}}{V_2^{\,k}} = P_1 \left(\frac{V_1}{V_2} \right)^{K} \qquad (2)$$

The points so obtained are then joined by a curve to make the usual diagram, which can be scaled to get the mean effective pressure. This method is necessary if it is desired for comparison with an indicator diagram taken from a compressor, but such a method of getting the m.e.p. for design or consideration work is far too laborious since a simpler one is available.

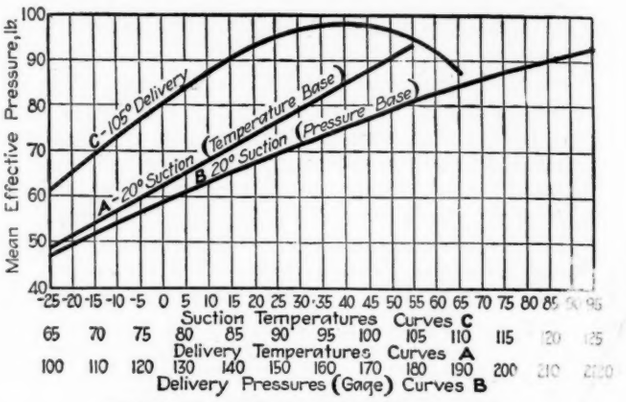
The same may be said of formula (1), and therefore the annexed table has been calculated, on the following basis:

$$K = 1.336 \qquad \frac{K}{K-1} = 3.9761 \qquad \frac{K-1}{K} = 0.25149$$

It will be noticed that the suction and delivery headings are given in temperatures. The refrigerating engineer always deals with these terminal points in temperatures when designing, and in the majority of cases steps of five degrees are quite sufficient for practical purposes.

However, to bridge the steps on the condensing side, it may be mentioned that as the m.e.p. has, at any given suction, an even increment for each degree rise of delivery temperature, a final column has been added giving that increment, and intermediate figures can readily be found.

The way to calculate these lines, say the 20-deg. suction line, is to use the formula (1) and calculate for


Mean Effective Pressure, lb.
100
90
80
70
60
50
40
C - 105° Delivery
A - 20° Suction (Temperature Base)
B 20° Suction (Pressure Base)
-25 -20 -15 -10 -5 0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95
Suction Temperatures Curves C
65 70 75 80 85 90 95 100 105 110 115 120 125
Delivery Temperatures Curves A
100 110 120 130 140 150 160 170 180 190 200 210 220
Delivery Pressures (Gage) Curves B

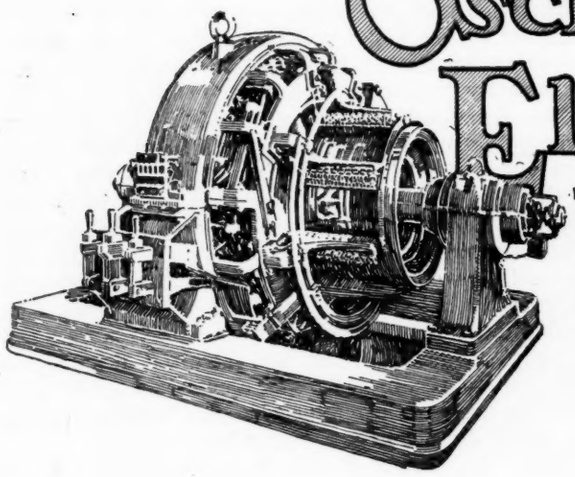
MEAN EFFECTIVE PRESSURE CURVE

20-deg. suction and 105-deg. delivery, which gives a m.e.p. of 93.028 lb. per sq.in. Now, evidently 20-deg. suction and 20-deg. delivery would give a m.e.p. of 0 lb., therefore a rise of 105 — 20 deg. = 85 deg. gives the rise of m.e.p., and 93.028 ÷ 85 = 1.094447, which is the increment per degree referred to.

The "curve," therefore, along any suction line on a temperature base is a straight line, and this fact has been used to check and correct the table, as shown at *A* in the diagram. The same line plotted on a pressure base is a curve, as shown at *B*. The curve *C* is that of the column headed 105 deg. delivery. These curves serve the useful purpose of conveying clearly to the mind the points referred to, as well as from curve *C* that there is a point of maximum m.e.p. which the table will locate and confirm. Further, it may be noted that the power rises, not with the pressure but with the temperature, which is therefore the true measure of the work done and the increment varies with the suction temperature used.

MEAN EFFECTIVE PRESSURES FOR AMMONIA COMPRESSORS

Suction or Refrigerator Pressure, Lb.	Absolute Pressure, Lb.	Gage Pressure, Lb.	Temp. F.°	Condenser Pressure, Lb. 118.03	129.19	141.22	154.10	167.88	182.62	198.35	215.12	232.98	Increment in Lb. per 1 Deg. Rise in Temp. of Condenser
				103.33	114.49	126.52	139.4	153.18	167.92	183.65	200.42	218.28	
				65	70	75	80	85	90	95	100	105	
16.17	1.47	—25		42.558	44.919	47.283	49.647	52.011	54.375	56.739	59.104	61.468	0.47285
18.45	3.75	—20		44.508	47.126	49.744	52.362	54.980	57.598	60.215	62.834	65.452	0.5236192
20.99	6.29	—15		46.281	49.174	52.067	54.959	57.852	60.745	63.637	66.530	69.422	0.578523
23.80	9.10	—10		47.821	51.009	54.197	57.385	60.573	63.761	66.949	70.137	73.325	0.637609
26.92	12.22	— 5		49.091	52.598	56.104	59.611	63.117	66.623	70.130	73.637	77.143	0.701305
30.37	15.67	0		50.033	53.881	57.730	61.578	65.427	69.276	73.125	76.973	80.822	0.76973
34.16	19.64	5		50.582	54.798	59.013	63.228	67.443	71.658	75.874	80.089	84.304	0.84304
38.34	23.64	10		50.695	55.303	59.912	64.520	69.129	73.738	78.346	82.955	87.564	0.92172
42.94	28.24	15		50.328	55.361	60.394	65.427	70.460	75.492	80.525	85.558	90.591	1.006566
47.85	33.15	20		49.250	54.722	60.195	65.667	71.139	76.611	82.084	87.556	93.028	1.094447
53.43	38.73	25		47.611	53.563	59.514	65.466	71.417	77.368	83.320	89.271	95.223	1.190283
59.42	44.72	30		45.208	51.666	58.125	64.583	71.041	77.500	83.958	90.417	96.875	1.2916
65.92	51.22	35		41.977	48.974	55.970	62.966	69.962	76.959	83.955	90.951	97.948	1.39925
72.99	58.29	40		37.826	45.392	52.957	60.522	68.088	75.653	83.219	90.784	98.349	1.5130735
80.66	65.96	45		32.585	40.731	48.878	57.024	65.170	73.317	81.463	89.609	97.756	1.629266
88.96	74.26	50		26.428	35.237	44.047	52.856	61.665	70.474	79.284	88.093	96.903	1.7168727
97.92	83.22	55		18.972	28.457	37.943	47.429	56.915	66.401	75.886	85.372	94.858	1.89716
107.59	92.89	60		10.194	20.388	30.582	40.777	50.971	61.165	71.359	81.554	91.748	2.03885
118.03	103.33	65		.....	10.934	21.868	32.801	43.735	54.669	65.603	76.536	87.471	2.18677



Oscillators on Electrical Machinery

By Clarence Lynn*

How oscillators came to be used on rotating electrical machinery. Different type of oscillators used. Proper method of staggering brushes to make commutator wear smooth. Oscillators are not required on modern type of rotary converters, and their use has been abandoned by one electrical manufacturing company.

PROBABLY the first use of oscillators on rotating electrical machinery was in connection with the operation of rotary converters in one of the substations of the Niagara Falls Power Co. in 1895. Generally the oscillator is thought of as belonging to the rotary converter, although its use has not been confined exclusively to such apparatus. In the days of non-commutating pole machines and before the development of the present types of brushes, the use of copper-leaf brushes on collector rings and of brushes of high resistance on the commutator was widespread. As current collection on the alternating-current end of a machine did not involve any electrical difficulties and as the copper-leaf brush was admirably suited, electrically, for this purpose, it was only natural that it should be used on the alternating-current end of rotary converters. On account of the high voltage per bar in the commutating zone, due to the lack of compensating devices, except the shifting of the brushes in the early types of direct-current machine, the use of a high-resistance brush on the commutator was imperative in order to limit the short-circuit current of the brush to such a value that successful commutation would result. A high-resistance carbon brush is usually a hard brush, and the result was that both the commutator and the collector rings became grooved with continual use of the machine.

In order to overcome the grooving effect, it was suggested that the rotating part be given a slight axial motion or oscillation so that the brushes would rub over the entire surface and thus do away with the grooving caused by the brushes dragging in one path continuously. It was found that under these conditions the oscillation of the armature did give some improvements.

There are two general classes of oscillators—one an electromagnetic type, which uses an electromagnet for pulling the shaft endwise, and the other a mechanical type, which makes use of mechanical devices of various sorts for giving the shaft a longitudinal motion in one direction. To give the shaft an axial motion in the reverse direction, the armature is so located, in respect to the field of the machine, that the operation of the oscillator moves the armature out of the magnetic center and the pull of the field moves it back to and past the center again, and thus the cycle is repeated.

The magnetic oscillator was first developed in a form in which the magnet was excited periodically by contacts located some distance from the rotary converter, the shaft being drawn toward the magnet when it was excited. As soon as the circuit was opened, the field poles would pull the armature in the other direction, and if the machine was properly installed, the armature would oscillate backward and forward several times and after a short interval of time the magnet would be energized again, thus repeating the operation. This type was improved by taking into consideration the natural period of oscillation of the armature, and the contact-making device was so constructed that it was actuated by the movement of the shaft and

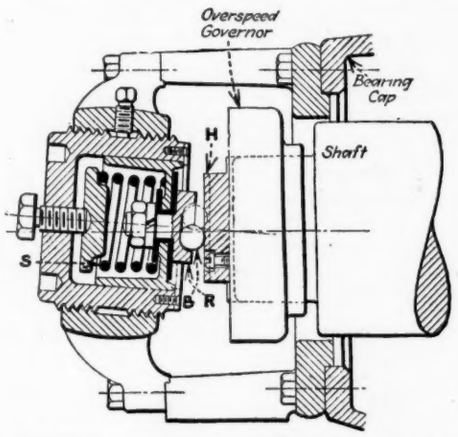


FIG. 1. SECTIONAL VIEW OF MECHANICAL OSCILLATOR

*Power Engineering Department, Westinghouse Electric and Manufacturing Company.

the magnet energized for each oscillation of the shaft. The chief difficulty with this type of oscillator is the trouble experienced with the contacts and in keeping them in permanent adjustment.

Like the modified magnetic type, the mechanical oscillator imparts to the shaft an endwise thrust for each oscillation of the armature. Fig. 1 gives a sectional view of one type of mechanical oscillator. From the figure is can be seen that there is a hardened flat steel faceplate *H* fastened to the shaft and a hardened circular steel ball race *R* with a hardened-steel ball *B*, running in between the ball race and the faceplate. The circular ball race is inclined from the vertical and

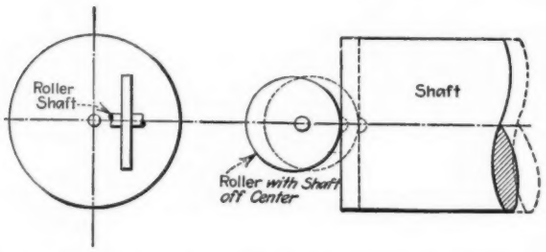


FIG. 2. ROLLER-TYPE OSCILLATOR. DOTTED LINES SHOW MECHANISM IN EXTREME POSITION TO THE RIGHT

pushed toward the shaft by a compression spring *S*, the force of which is regulated by a screw in the rear of the oscillator sleeve. A circular ring stop limits the ball-race bushing in its motion toward the shaft. The oscillator sleeve is screwed into the bracket in such a manner that, should it become loose, the rotation of the shaft will tend to screw it away from the shaft and thus not pinch the latter up against the bearing.

As the shaft moves toward the oscillator, the hardened steel ball rotates upward in a circular path between the ball race and the faceplate compressing the spring. The reaction of the spring forces the shaft away from the oscillator, and the ball is caused to drop to the bottom of the ball race. In high-speed machines trouble was experienced at first with the ball, which would not drop to the bottom of the ball race as soon as the shaft was pushed away from it, but owing to its momentum it would continue to rotate in a circular path in the ball race and the shaft would sometimes come into contact with the ball when it was at the top of the race instead of at the bottom, thus giving the shaft no oscillation. If there was any shaft magnetism present, it would tend to help hold the ball in the race, but this is minimized by the use of insulating washers. The difficulty was overcome by the use of a small flexible wire placed between the ball race and the end plate of the shaft in such a manner that the ball, instead of continuing in a circular path after it had reached the top of its travel, would strike the spring wire and would drop to the bottom of the ball race in readiness for the next oscillation. In some cases the shaft of the machine is given a small inclination from the horizontal in a direction toward the oscillator end. This will assist the armature in returning toward the oscillator.

Another mechanical oscillator is the roller type, shown schematically in Fig. 2. This consists essentially of a disc roller with its axis off center and so mounted that it is rotated by friction drive with the end of the shaft of the rotary. The shaft of the converter would be pushed away from the shaft of the roller as the latter turned, as shown by the dotted lines of the figure. This type was never very extensively used. Both roller and ball oscillators were subjected to the difficulty of the roller and ball pitting if any current flowed in the shaft. However, this could be overcome by properly insulating parts of the oscillator.

There was another type of oscillator which differed radically from any mentioned so far, and this was the type which oscillated the entire brush rigging parallel to the shaft. It was designed primarily to be used where the oscillation of the shaft was impossible. A motor was used to drive the mechanism, and the rate of oscillation was extremely slow in comparison with the rate when the ordinary oscillator was used. The troubles attending the use of this oscillator were due to its complicated construction and the use of flexible leads connected to the brushes. If application was limited almost entirely to the engine-type direct-current generator, and it did not have a very wide use.

When the oscillator was first developed and for many years afterward, it really had a field of usefulness, but with the progress of the electrical art the need for it has disappeared owing to the overcoming of the obstacles which first necessitated its employment, although oscillators continue to be used apparently for no other reason than precedent. On such classes of electrical machinery as engine-type generators and geared units, where the use of an oscillator was attended with many complications, the absence of such a device has caused no particular hardship. By the elimination of the oscillator the troubles and difficulties attending its use have disappeared.

In stating the reason for the discontinuance of the use of the oscillator, both the electrical and mechanical reasons should be considered. On the direct-current end

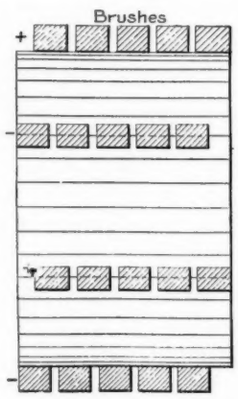


FIG. 3. BRUSHES INCORRECTLY STAGGERED ON COMMUTATOR

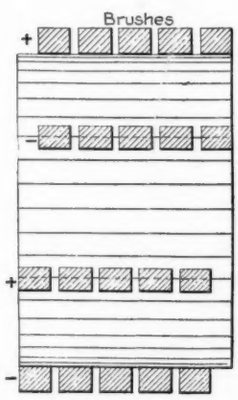


FIG. 4. BRUSHES CORRECTLY STAGGERED ON COMMUTATOR

the use of commutating poles and in the case of high-speed motor-generator sets, compensating winding, has reduced the resultant volts per bar under the brush to such a value, that with a low-resistance brush excessive local or short-circuit currents will not flow in the brush. This means that a soft brush, generally with some lubricating qualities in it, can be used with less wearing away of the commutator. Besides the actual frictional wearing away of the commutator by the brushes, there is a burning action which takes place under the brush and which is more effective in wearing away and grooving the commutator than the actual brush friction. The

burning effect under the positive brushes is different from that under the negative ones. This burning, like that of the ordinary arc, acts in such a manner that particles of material are carried in the direction of the current flow. Thus, in the case of the positive brush of a generator and the negative brush of a motor, copper of the commutator is "eaten away" and partly deposited upon the brush, and on the opposite polarity brushes the brush is eaten away. When the brushes are not staggered or all brushes of one polarity are staggered from all brushes of the other polarity, as in Fig. 3, the

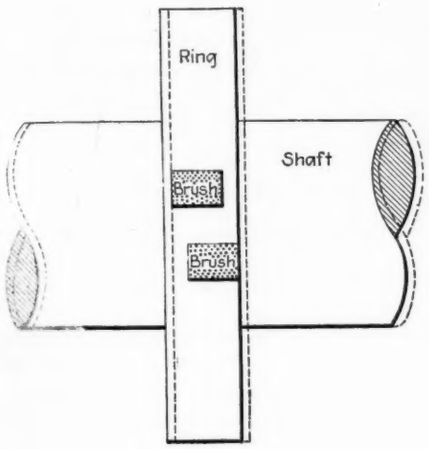


FIG. 5. STAGGERING OF BRUSHES ON COLLECTOR RING. DOTTED LINES SHOW RING AND SHAFT IN EXTREME POSITION TO THE RIGHT WHEN OSCILLATOR IS USED

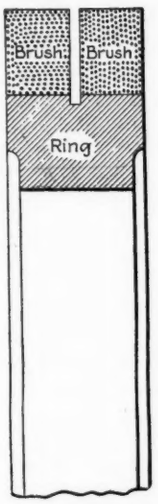


FIG. 6. LATEST TYPE OF UNDERCUT COLLECTOR RING WITH TWIN BRUSHES. NO OSCILLATOR

aforementioned action would tend to groove the commutator, especially under the brushes where the current flows from the commutator to the brushes. An oscillator was used to overcome this, but instead often made the action worse, since when the oscillator shifts the armature to one side, the brush, which in the normal position is running in the center of the groove, is caused to rise and rides on one edge only. This causes reduced contact between the brush and the commutator or collector ring, as the case may be, and excessive burning of these parts results. However, if the brush arms be staggered in pairs, as they should be (see Fig. 4), then the burning action will not be confined to definite paths, causing grooves, but will occur over the entire surface of the commutator; and if a brush of the right composition be used, the scouring action of the brushes will keep the commutator smooth and give it a good polish.

On the alternating-current end copper-leaf brushes have been superseded by composition brushes containing carbon, graphite and some metal, generally copper. As the capacities of rotary converters increased, it became impossible to get enough copper-leaf brushes on the collector rings to carry the current because of the angle at which they must run with the rings. By the use of the alloy brush the cutting of the rings and brush itself, which was a very objectionable feature with the copper-leaf brushes, was modified considerably. When alloy brushes were first used, they were staggered as shown in Fig. 5, so that when the ring moved sidewise, owing to the oscillation of the armature, its entire surface passed under some part of the brush. It can be readily seen that, because of this staggering, the central part of the ring is subjected to more wear than the outer edges, and even with the use of an oscillator the rings would become grooved in the center. If the brushes were not staggered, the central part would still become grooved as this part of the ring would always have part of the brush rubbing upon it when the oscillator pushed the armature to one side. If a single brush, wide enough to cover the ring and its movement due to oscillation, were used, the brush face would be worn to a concave shape which, with oscillation, would cause poor contact. Without the use of an oscillator a brush the same width of the ring can be used without difficulty with either ring or brush wear. In the case of large-capacity machines, the arrangement shown in Fig. 6 is used with a double ring and twin brushes and holders. This has been found desirable, as the use of several small brushes will give a better contact with the ring than the use of a lesser number of large ones. It has been found in actual practice with the brushes arranged as above and with no oscillator used, that the rings do not groove as much as if an oscillator were used.

Thus it appears that there is no more need for an oscillator on a rotary converter or a motor-generator set than there is for one on an induction motor or an ordinary engine-type direct-current generator and that there is more to be gained by its omission than with its use. The Westinghouse Electric and Manufacturing Co. has been supplying for over a year rotary converters and motor-generator sets without oscillators, even though some engineers and operators may still feel that a rotary converter is incomplete without an oscillator.

Moody Spiral Pump

A desirable feature in a pump is high speed, inasmuch as such a pump can be installed at less cost, because it can be made smaller and lighter in design and requires less floor space than a slow-speed pump.

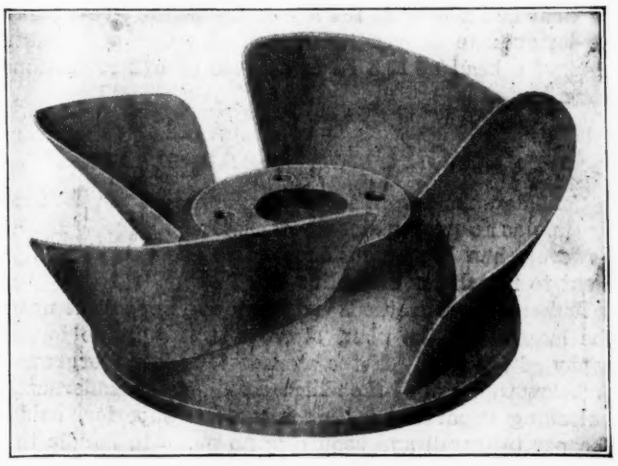


FIG. 1. DESIGN OF THE PUMP IMPELLER

A low- and medium-head high-speed pump has been designed by the I. P. Morris Department of the William Cramp & Sons Ship and Engine Building Co., Philadelphia, Pa. Fig. 1 shows the design of the impeller, and Fig. 2 shows a sectional elevation of the pump.

In design the spiral pump is simple. The impeller is of the single-suction type, and as it is overhung on the end of a shaft, but one bearing and one stuffing box are required. The openings between the impeller vanes are large, and an impeller of 18 in. outside diameter will pass a 3-in. cube through the smallest section. This feature of design decreases the danger of plugging the pump with foreign material.

The design of the pump also reduces the leakage that occurs at the seal of the impeller; therefore the clearance between the impeller and the stationary part may be made comparatively large, thus reducing the effect

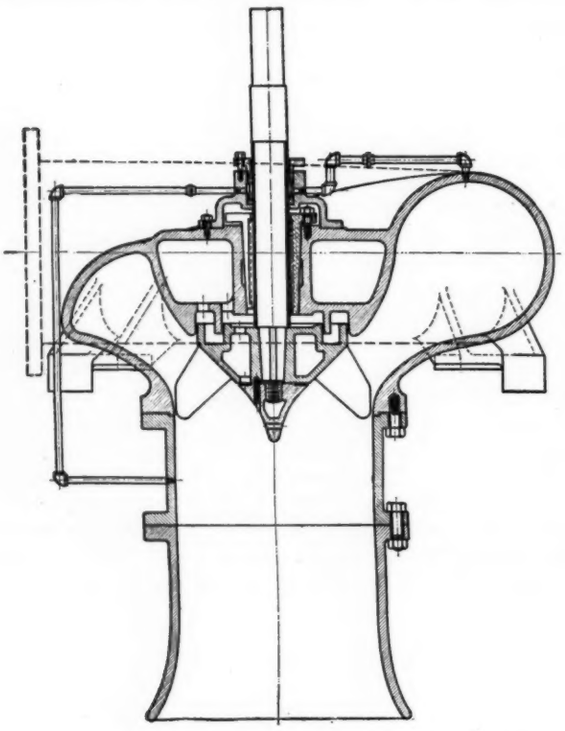


FIG. 2. SECTIONAL ELEVATION OF THE PUMP

of wear and adding to the life of the pump. This pump is designed to deliver 12,000 gal. of water per minute against a head of 16.5 ft. at a speed of 672 revolutions per minute.

Fuel-Oil Unloading Apparatus

Considerable information has appeared from time to time as to proper storage tanks for oil fuel. Little, however, has been mentioned as to the proper equipment to install for unloading purposes.

Either of two methods may be used, dependent upon the location of the plant storage tank and the topography of the land. If the storage tank is underground or below the level of the railroad siding, the underneath unloading apparatus is in many ways superior, being cheaper to install and requiring no pump to handle the oil. Fig. 1 shows this arrangement. The unloading piping is attached to the fuel line leading to the storage tank. The pipe line should be anchored, preferably to a concrete block, to prevent any displacement of the pipe line. The swinging joints may be any of several well-known makes. Undoubtedly, a ball-and-socket arrangement having a soft metallic gasket is the best. The two joints of pipe should be several feet longer than the distance to the center of the railroad track, as this allows connection without an exact placement of the car. The pipe is much superior to flexible hose. The pipe size may be as desired, although a diameter above two

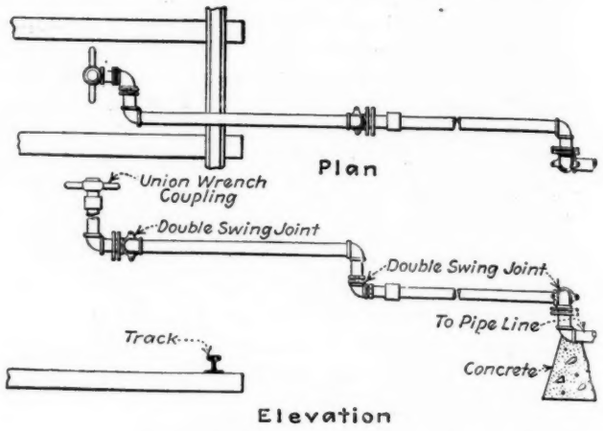


FIG. 1. UNDERNEATH UNLOADING APPARATUS

inches should be chosen. The tank coupling can be obtained from any supply house.

Where the storage tank is placed above the track level, the overhead unloading system is advisable. It has the advantage of providing ample clearance along the track. Furthermore, there is no danger of loss of oil due to defect in the unloading coupling. The platform should best be set at least eight feet from the near rail and should be ten to twelve feet above ground. Fig. 2 gives the various dimensions as recommended by the Bessemer Gas Engine Co. The drawing shows

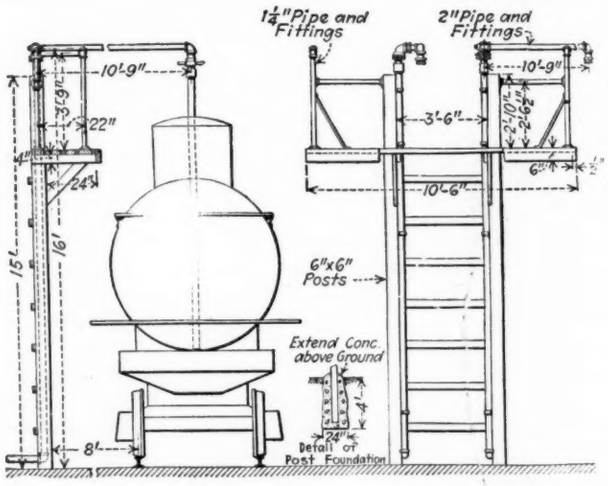


FIG. 2. OVERHEAD UNLOADING APPARATUS

two unloading pipe lines, although one is sufficient. In the Northern states fuel oil often is very sluggish to handle and it becomes necessary to install a steam pipe line to the tank heater coils. This line can be placed on this unloading rack without interfering with the fuel oil.

The successful operation of a semi-Diesel oil engine depends more on the action of the fuel pump and atomizer than on all other factors. An operator should give close attention to these two details. Another detail of great importance is the cleanliness of the engine and engine room.

Latest Developments in Large Boilers for Central Stations

IN A recent issue of *Power* there was published an article on the Springdale Power Station[1] in which brief reference was made of the boilers, which were designed and built by the Babcock & Wilcox Co. These boilers represent one stage in the evolution of a new type which the company regards as one of the most important contributions it has made to the betterment of steam engineering. The history of this special type of boiler is about as follows:

About five years ago the late Henry G. Stott decided to use duplex furnaces under the boilers of a power station he was designing for the Buffalo General Electric Co., and the Babcock & Wilcox Co. designed in co-operation with him a type of boiler for 250 lb. pressure and 250 deg. superheat at the throttle. It was 11 tubes high, with the superheater placed, as usual, above the water tubes, and a large economizer supplemented each boiler unit.

For such heavy service as was expected from this plant, duplex furnaces burn coal more economically than single furnaces, for a given boiler output, because of their higher ratio of grate to heating surface. But the large volume of gases from duplex furnaces is at a very high temperature when the boiler is heavily loaded, and so the bottom baffling was placed above the bottom row of water tubes in order that these tubes, by absorbing heat from the gases, might aid in keeping the furnace temperature below the point where the brickwork is seriously affected. As is known, this boiler plant has been very efficient.

The Springdale installation represents the next step in the development of this type. These boilers are 16 tubes high, and the bottom two rows of tubes are below the bottom baffling. They were designed for 350 lb. working pressure and about 200 deg. superheat. Space has been provided for installing economizers later if load and fuel-cost conditions warrant their use.

The Babcock & Wilcox Co. next utilized the new methods of securing great capacity and flexibility in service in its designs for the boilers for the Colfax Power Station of the Duquesne Light Co.[2] Those boilers are 18 tubes high and were built for a working pressure of 275 lb. and about 250 deg. superheat. It is not planned to use economizers with them.

Early this year the company was asked to design boilers for 275 lb. working pressure and 225 deg. superheat for a large central station. After an exhaustive study of the conditions, it designed the boiler illustrated. Economizers are not provided, although space is left for them if an advance in the price of coal justifies their installation at some later date. The net efficiency of these boilers with economizers, estimated in the light of the best current economizer operating results, compared with the net efficiency of the boiler illustrated, without economizers, did not justify the investment in economizers with coal at the present prices. The company considers that this type of boiler will prove a coal-saving and efficiency-maintaining unit of unusual value for high or low load factors.

The notable increase in the load factor of central power stations resulting from the increased general use of electricity, coupled with the high cost of fuel, has forced consideration of more efficient distribution of the heating surface of boilers. The type developed as a result of exhaustive studies for several years along this line is shown in the accompanying illustration, and a short description follows.

The boiler, designed by the same company and of the cross-drum type, is divided into two decks with six tubes in the lower deck and fourteen in the upper, making twenty in total height, the tubes being 20 ft. long. The six tubes of the lower deck are exposed for their full length, without baffles, to the radiant heat of the furnace. This construction increases the total heat absorption through direct radiation and tends toward keeping the furnace temperature at a point where the upkeep of the brickwork is at a minimum.

Furthermore, the construction gives such a large and easy entrance for gases into the boiler-heating

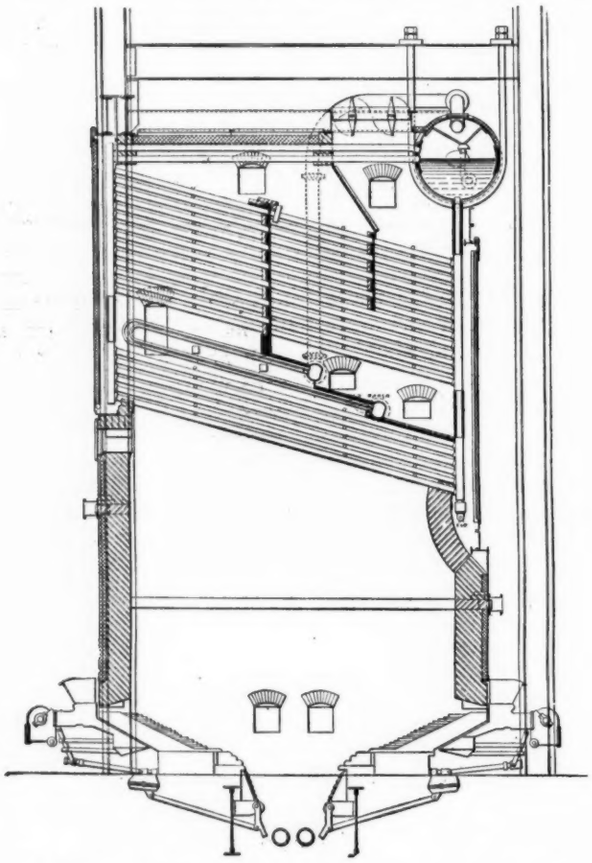
[1] Page 488, Sept. 28, 1920.

[2] A description of this plant will be published in a later issue.

surface that the probability of slagging between tubes, where the gases are hottest, is remote even at the highest rates of combustion and with high-ash coals.

The superheater is located immediately above the lower deck of boiler tubes. This location in the setting, where the gases have not been cooled to a point approaching that existing in what has come to be looked upon as standard superheater location in horizontal water-tube boilers, enables practically any desired degree of superheat to be obtained with a minimum amount of superheating surface and a corresponding minimum superheater cost.

The upper bank of fourteen tubes is baffled after the standard methods of the company. The great length of gas travel at the high gas velocity, following from



RECENT DEVELOPMENT OF THE TWO-DECK, CROSS-DRUM BABCOCK & WILCOX BOILER

the burning of sufficient fuel to give capacities per square foot of heating surface corresponding to those obtained in lower boilers, results is an increased rate of heat transfer for the design illustrated. This tends toward the lowest practicable exit-gas temperatures and hence the highest boiler efficiencies.

The boiler is equipped with a duplex furnace of ample volume, such as was originated by the late H. G. Stott. With such a furnace, even at the highest boiler capacities, the combustion rate, expressed in pounds of coal per stoker retort per hour, will be at an efficient rate from the standpoint of stoker operation and upkeep.

The boiler, as illustrated, contains 452 sq.ft. of heating surface per section of width. At the present time the company is equipped to build units of this character up to and including 51 sections in width, which would give a total heating surface of 23,050 sq.ft. The heating surface will vary with the ultimate steam temperature required. Boilers of this general design would ordinarily be used in a base station where the load factor is high. The superheating surface installed would be such as to give the desired ultimate temperature at normal operating load.

With the setting height indicated in the illustration the furnace volume would be approximately 3.95 cu.ft. per so-called rated boiler-horsepower.

In the largest unit that could be built 32 retorts of underfeed stoker could be installed. If a chain-grate type of stoker were installed rather than underfeed, assuming the length of the chain grate to be 17 ft., the total grate surface would be 459 sq.ft., giving a ratio of 1:41.5.

Departures From "Accepted Designs"

BY W. D. FORBES

THOSE who go about among machinery notice at once any departure from what are called "accepted designs." This I have observed almost always in men who have charge of steam engines. We are prone to stick to what has proved satisfactory in engine building. This is wise up to a certain point, and when it comes to engines, pumps, blowers, etc., which have to work about all the time, and where the supply house is miles away, men who have to care for machines are justified in being slow to try out new things.

In looking over my notes I came across some departures from the usual which may prove interesting to *Power* readers. The relief valves that are supplied with most engines are usually made in one of two ways; that is, those that scald you when they lift, if you are on duty, and those that are piped off so that you cannot be scalded. I have often seen relief valves so made as to be piped, but I cannot recall many cases where the piping has been done. Generally, the screwed opening is placed so as to do as little scalding as possible and it is let go at that.

The specifications for relief valves are usually rather "misty" and read about like this: "Relief valves shall be furnished of sufficient size to relieve any pressure in the cylinder caused by trapping water therein." Never but once have I seen anything regarding the increased clearance that relief valves might produce.

AN UNUSUAL RELIEF-VALVE IDEA

The first odd relief-valve I ever saw was on a German engine, made, I think, by a man named Maur. Both front and back cylinder heads were fitted with ground joints, and under the nuts of the studs holding the heads in place were spring washers, so that if water was trapped the entire head lifted. This was regarded as a very fine idea. It was several years later that I had to inspect some chocolate machinery in Holland, and there I found that same engine, but the spring washers were no more and in their place were the regular finished washers usually found on foreign engines under the stud nuts. So I do not think the system worked very well.

In another foreign make the builder of a very high-grade engine was proud indeed of his relief-valve system. In his piston there were four valves, two facing one way and two the other. The builder explained that if water was trapped in the cylinder the valves in the

piston would open and the water would escape to the other side of the piston. He seemed "peeved" when I questioned the wisdom of dumping water that was not wanted on one side of the piston to the other side where it was not wanted either.

Meeting the Demands of the Navy Department

I received an order for some engines from the United States Navy, Department of Steam Engineering, and when you build engines for that department you have to have all drawings approved before you start work or you will get into trouble. In the specifications for the engines there was a demand requiring the relief valves to have a certain area and to be so placed that the increased clearance would not exceed a certain percentage of the cylinder volume.

There was no trouble in meeting these demands on the head end, but as the engines were small, only 4½-in. bore, I struck trouble on the crank end. Admiral George Melville was then the Chief of the Bureau of Steam Engineering, and it was a pleasure to do business with him. I worked hard in getting the relief valves to suit and made several trips to Washington with drawings, but I could not quite reach the requirements as to reduced clearance. The Admiral at last said that he thought what I had was close enough to the demands and that he would approve my last design. Just at the end of the interview the whistle blew, so to speak, and I was obliged to leave to return next day.

On my way across La Fayette Square to my hotel I happened to remember the spring-washer idea of Maur's, and when I went to the Army and Navy Building the next day I had the relief valve for the crank end of my engines down to the requirements, much to the Admiral's delight. Shortly after I sent on finished drawings and built the engines with the head-end relief valves constructed this way.

Instead of having the cylinder head lift I made the entire stuffing box for the piston rod lift, acting as a relief valve. In fact, the crank end of the engine had its head cast solid. The stuffing box I made of composition, and I easily got the area wanted and kept the clearance below specifications. I know that this system worked well, as when the torpedo flotilla was taken out to the Philippines by Commander Cone he reported that "the Forbes blower engines were a delight." Now anybody who has been to sea and can say he has a blower engine that is a delight has met a rare bird or his head has been affected by the heat of the engine room. I was very proud of those engines, as I think I had the right to be.

Dopp Relief Valve for Locomotives

Out in Buffalo, N. Y., when Frank Wilder was master mechanic of the Western division of the Erie railroad, a man by the name of Dopp, I think, brought out a relief for locomotives, and Mr. Wilder put on several. This valve answered not only as a relief valve but also as a drain cock; in fact, it was an automatic drain cock, but if used it made the relief valve unnecessary, and that, in fact, was its idea. The body of the valve was T-shaped and was connected up with the outlet looking down, while the ends were piped up to the regular drain-cock holes. There were two seats in the body, one on each side of the opening. These two seats were closed by two cone-shaped hollow clappers, and the larger ends of the two clappers were ground to the two seats in the body, and between them was supplied a small bar of composition just long enough to push one of the valves off its seat when the other was seated; therefore both valves could never be closed at the same time. When the steam pressure struck the valves, say on the head end, it closed that valve and no steam could escape; when the steam came on the other end of the cylinder the other valve closed; the bar between them acted if necessary.

As the two clappers on the valves were cone-shaped, when the steam was off both ends of the cylinder the clappers lay on the bottoms of the body of the valve; therefore both seats were uncovered, giving a free passage for water. I could see but one objection to this arrangement, and that was that it might be costly in steam consumption. The Dopp valve, if I have the name right, was designed with the idea that if the cylinders could be always automatically drained relief valves would not be necessary, which is of course correct.

The "Bangs" Oil Cup

I built several compound engines some years ago for marine use, and on one of them I was directed to put the "Bangs" oil cup on the crankpin end of the connecting rod. I ordered the cups, and Mr. Bangs brought two cups to fill my order and to explain them to me. Instead of having the usual hole in the bottom of the cup there was a rib cast on the inside which ran from the bottom to within ⅛ in. of the top. In this rib a very small hole was drilled with about a No. 40 drill, and this small hole was connected with a hole drilled to meet it, reaching a somewhat larger hole in the stem of the cup. Just above the small hole in the rib was a spoon-shaped piece of metal set with the hollow facing the center of the cup. The cup had to be set in the rod so that the oil would throw against this spoon and it then ran down onto the top of the rib, which was countersunk just a little. When the engine was standing still no oil could feed, as is evident, and when in motion oil was thrown into the spoon.

I was not at all impressed with the system, as I thought the small hole would get plugged up, but I was assured by Mr. Bangs that if I drove a hickory peg into the small oil hole it would not stay there. I tried the experiment and Mr. Bangs was right; the peg would not stay in the hole. This cup saved a great amount of oil and yet oiled the crankpin perfectly. I think only about one-eighth the amount of oil was needed when this cup was fitted, yet I never saw a dozen of them in all my life. Now, why not? It was a good thing and a money saver, but so far as I know it was little used.

To scrape a Diesel bearing, the journal should be coated with lampblack. Placing the bearing on the shaft and giving it a rocking motion, the high spots in the bearing will be coated with black and can be scraped down. If commercial lampblack to use in scraping bearings is not obtainable, a good substitute can be made of soot from the exhaust mixed with lubrication oil.

The Baumé gravity has no direct bearing on the adaptability of a fuel oil. It happens, however, that most oils have a gravity fairly in proportion to their adaptability as a fuel oil. With Mexican untopped oil of 16 deg. Bé., enough gasoline is present to produce the primary ignition.

The Continuous Testing of the Power-House Plant

By A. S. TROLLIP

THE late P. W. Willans pointed out in his paper, "Steam Engine Trials,"[1] that if the steam consumption per hour of a constant-expansion or throttling engine be plotted against the horsepower, the result is an oblique straight line, as shown in Fig. 1.

The equation to the curve is represented by

$$Q = a + bP$$

in which Q equals the total weight of steam used per hour; P equals the horsepower; a equals the weight of steam used at zero mean pressure, depending on the extent of the back pressure and on the inherent losses of the engine; and b equals a constant, depending on the type of engine. It follows that this relation will hold for a turbine running with constant vacuum and constant speed.

Several engineers, among them R. H. Parsons, have shown that a power house, considered as an organic whole, follows the same law. The performance can be represented by two equations connecting the:

1. Coal consumption and water evaporated; which may be termed the boiler-house characteristic.
2. Steam consumption and kilowatt-hours generated; which may be termed the engine-room characteristic.

These two equations can be combined and again represented by a straight line connecting the coal consumption and the kilowatt-hours. This curve may be conveniently termed the power-house characteristic.

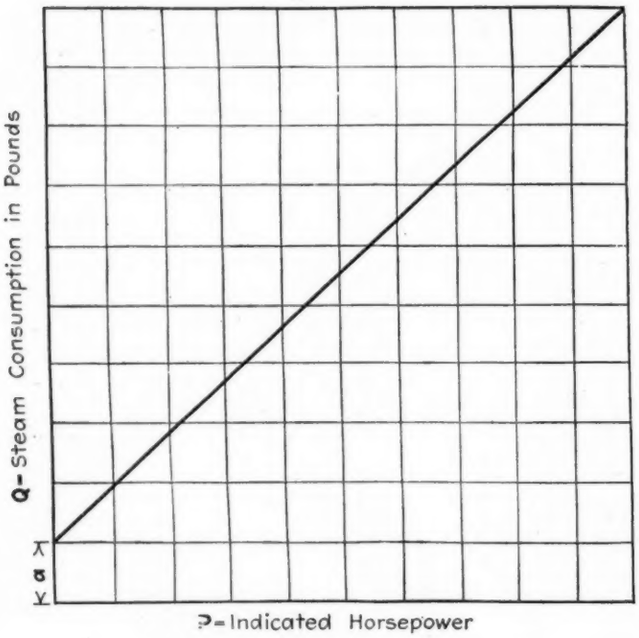


FIG. 1. WILLANS LINE: $Q = a + bP$

The writer has found from an analytical investigation of the financial figures for a power-supply company, that an equation can be obtained connecting the costs of whole of the supply undertaking with the units delivered to consumers. It can, as before, be represented by a straight line. This relation may be termed the financial characteristic.

To illustrate these most important characteristics, the equations for a turbo-generator station equipped with watertube boilers will be considered:

Let C equal weight of coal fired in pounds per shift; W equal weight of water evaporated in pounds per shift;

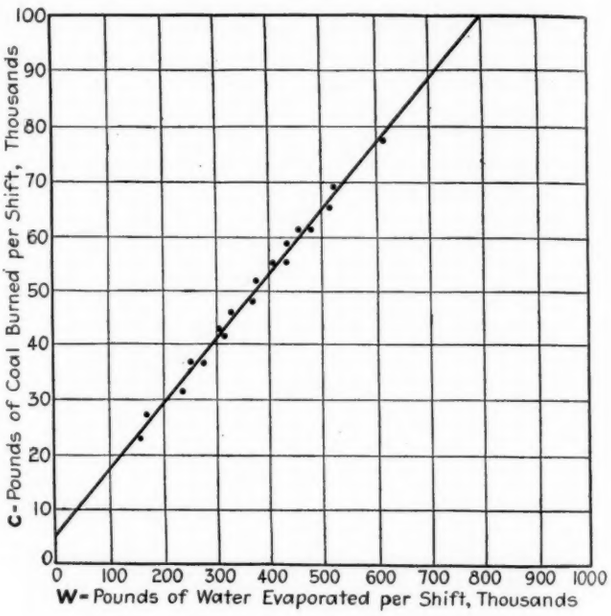


FIG. 2. BOILER-ROOM CHARACTERISTIC

A equal weight of steam losses; S equal weight of steam condensed per hour; and K equal output of units per shift.

Boiler-House Characteristic

If the figures for the coal consumption in pounds and the water evaporated in pounds over a given period—an hour, a shift, twenty-four hours or a month—be plotted, it will be observed that the successive points lie approximately on a straight line.

In the example considered, Fig. 2, the readings have been taken over a period of a shift of eight hours. Readings taken over shorter periods are likely to give inaccurate results due to errors of water level and amount of fire on the grate.

An average line can be drawn through these points; it will be observed that the line cuts the ordinate axis at a point that represents the no-load losses.

This curve has an equation of the form $C = a + bW$; the values of a and b can be found by means of simultaneous equations.

The equation for the curve represented in Fig. 2 has the value

$$C = 4{,}620 + 0.12\,W \qquad (1)$$

Interpreted, this means that 4,620 lb. of coal is consumed per shift to provide the following losses: Radia-

[1] *Proceedings* Inst. C. E., vol. cxiv, p. 2.

tion, steam leakage, banking fires, etc. After these losses have been met, there is an expenditure of 0.12 lb. of coal per pound of water evaporated.

Engine-Room Characteristic

Similarly if the steam consumption per shift be plotted against the output in kilowatt-hours, they, too, lie approximately along a straight line. (See Fig. 3.)

The equation to the curve for the station we have taken as an example is represented by

$$W = a_1 + b_1 k$$
$$W = 34{,}833 + 15.k \qquad (2)$$

meaning that 34,833 lb. of steam is used every shift in

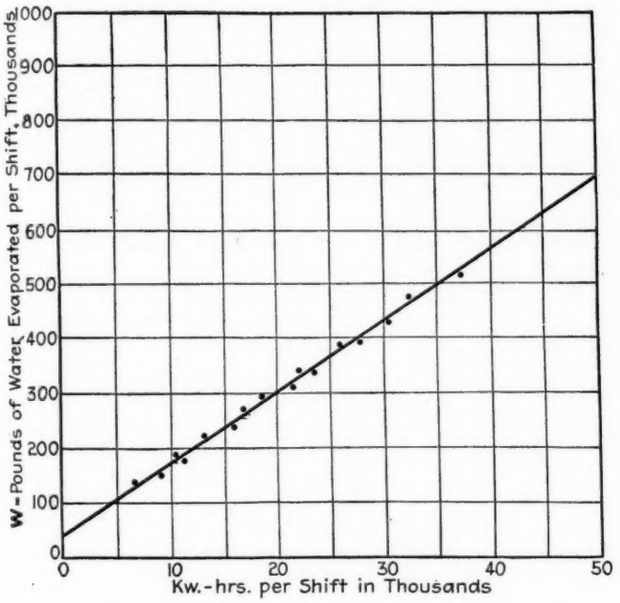


FIG. 3. ENGINE-ROOM CHARACTERISTIC

supplying the losses due to leakage, condensation, etc.; 15 lb. of steam is supplied per kilowatt-hour generated.

Power-House Characteristic

If the coal fired per shift be plotted against the units generated per shift, they will be found to lie on a straight line, Fig. 4, having the form

$$c = a_2 + b_1 k \qquad (3)$$

The equation represented is made up of the boiler-house and engine-room characteristics and may be found from equations (1) and (2) as follows:

$$c = a + bw \qquad (1)$$
$$w = a_1 + bk \qquad (2)$$
$$c = a + b\,(a_1 + bk)$$
$$c = 4{,}620 + 0.12\,(34{,}833 + 15\,k)$$
$$c = 8{,}800 + 1.8\,k \qquad (3)$$

in which the total coal fired is made up of 8,800 lb. to cover losses due to radiation, blowoff, steam leakage, etc., and 1.8 lb. per kw.-hr. produced by the plant.

The characteristic for the individual units in a station connecting the steam consumption (s) and the kilowatt-hours generated (k) can be obtained in the same way. It is of the form $s = a + bk$. The performances of the individual units in the example under illustration are, unfortunately, not in the writer's possession. For a station that is now under analysis consisting of 6,000 kw. Curtis turbo-generators, the machine characteristic is represented by $s = 62{,}400 + 12$ kw. If we subtract the equation representing the machine characteristic from the equation representing the engine-room characteristic, we obtain $w - s$, the amount of water or steam lost by condensation, etc.

The Value of Continuous Testing

Continuous testing permits of a continuous check on the coal and steam consumption. Losses are detected and localized during the shift in which they occur.

It also provides a means of comparing the performance of stations. The constant or no-load losses are chiefly dependent on design. The consumption of coal and water, which are proportioned to the load, are dependent upon the efficiency of the whole plant and on the efficiency of operation.

In practice these results are achieved by plotting the characteristics on squared paper. Upon the completion of a shift the engineer plots the several points on the chart. If the points are on or below the characteristic, all is well; if the point is above, a loss is signified, which, as was pointed out under the heading of division of losses, may be traced definitely to either the boiler house or the engine room.

The value of this method is great, for it provides not only a continuous check, but a means of testing the station as a whole.

The method provides a ready means whereby an equitable bonus system may be used. In most plants the bonus system is not applied because of the impossibility of securing the necessary data save at prohibitive cost. With the method under discussion, after the several constants of the plant have been secured, it

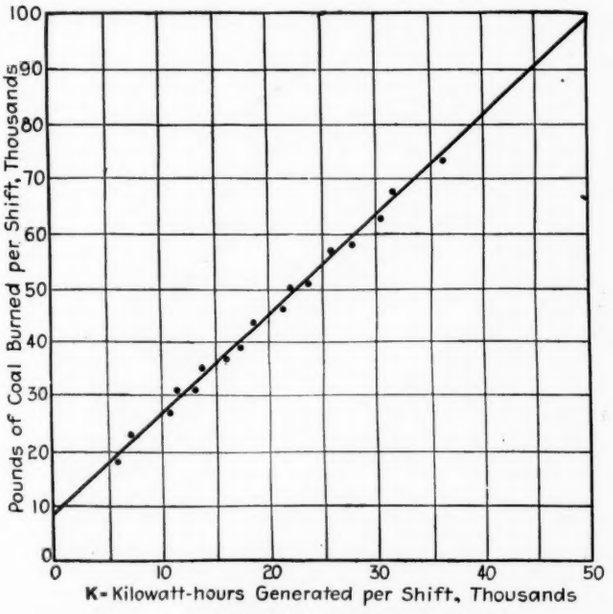


FIG. 4. POWER-PLANT CHARACTERISTIC

requires but a few minutes' calculation at the end of a shift to determine the economies secured and the bonus earned.

Requirements for Testing

As will be gathered, the following measurements are required: Coal fired, water evaporated, steam consumption of each turbine or other unit, units generated by each generator, and weight of the makeup feed water.

The coal is best weighed by an automatic coal-weighing machine. Volume measurement is crude. There are numerous methods of measuring the feed water, steam condensed, etc. Judging from the number of V-notch recorders in use, this method is giving good results.

Financial Characteristic

This characteristic is obtained by plotting the monthly costs of the whole of the supply undertaking—namely, generation, distribution and management expenses—against the number of units sold to the consumer. The characteristic consists of two parts:

1. The costs incurred which are necessary for the system to be in a position to deliver to the customer. They include what are generally known as the fixed costs; namely, depreciation and amortization, and salaries, wages, cost of no-load losses of the station, etc.
2. The costs which are proportional to the load; namely, the greater proportion of coal, oil, waste, repairs, etc.

This characteristic is of extreme value to the management, who can at a glance compare costs of any month, without falling into the error of comparing costs per unit delivered to the consumer upon the basis of unequal production.

The Speed Limit of Ball Bearings

By W. J. A. London

The maximum safe speed at which ball bearings can be operated is one of vital importance when considering the application of such bearings to high-speed machines. Unfortunately, the only formulas available, as published by the ball-bearings makers, are very ambiguous on this point. Again, the rating tables, as issued by the various makers, are, in the writer's experience, too idealistic to be followed indiscriminately in practice. The earlier formulas ignored speed altogether, while some of the later ones published introduce a "*k*" for speed correction.

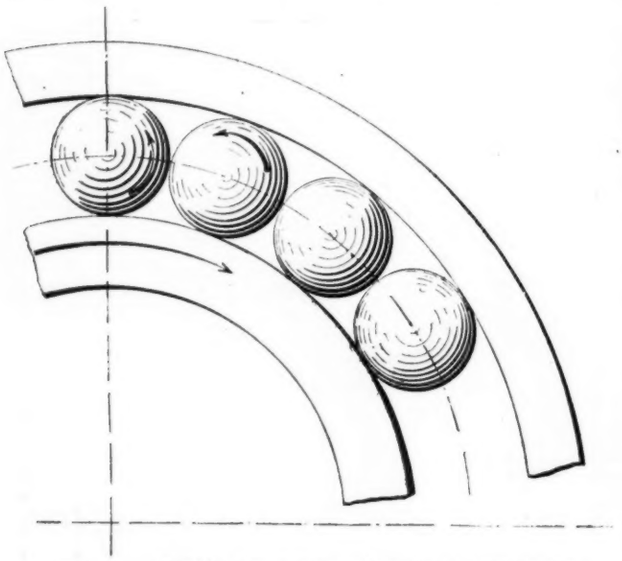


FIG. 1. ACTION OF A PERFECT BALL BEARING

The following arguments are advanced in criticism of all existing formulas in that they do not, in the writer's opinion, take into consideration the major factors that enter into this so-called safe speed limit.

In a theoretically perfect ball bearing, if it were possible to operate such a one, the actual speed limit would be reached when the specific journal load plus that due to the centrifugal force of the balls reached the breakdown point of the material in the balls and races. With the actual loads used in practice compared with the safe load standing still, and making calculations for the centrifugal force of the balls, it will be found that the speed limit is so high that it

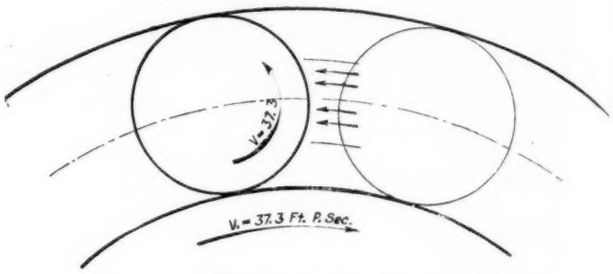


FIG. 2. VELOCITY OF BALLS AND RACE

can rightly be ignored, as it is so far beyond any commercial requirements.

Still considering the perfect bearing, no lubrication is necessary, as true rolling motion only is supposed to exist. A perfect ball bearing, however, cannot be operated, inasmuch as a retainer must be introduced to separate the balls, otherwise they would rub together in opposite directions as shown in Fig. 1; and experience has shown that a safe speed limit is reached long before the calculations of the perfect bearing indicates.

We can, therefore, in considering this subject from a practical standpoint, absolutely ignore the performance of the balls in the races and confine ourselves exclusively to the performance of the balls in the retainer. An analysis of what actually takes place in a bearing will, the writer believes, prove the correctness of the foregoing contention. Take, for instance, a ball bearing having a mean diameter of 3 in. with $\frac{5}{8}$-in. balls operating at 3,600 r.p.m. The speed of the inner race will be 37.3 ft. per second, so that without slippage the peripheral speed of the balls will also be 37.3 ft. per second, as indicated in Fig. 2.

Any retainer must be built so that there is a bearing surface between any one ball and the adjacent section of the retainer. As the balls drive this retainer around, these contact surfaces are in reality a series of little sleeve bearings or shoes. Fig. 3 shows a typical ball bearing with a retainer ring. The surface speed with the example given has been shown to be 37.3 ft. per second. This in itself is considered a high speed in practical sleeve-bearing operation with ring lubrication. Furthermore, it must be borne in mind that no antifriction metal is introduced.

It may be contended that while the surface speed is high the load per unit area is apparently negligible. This, however, is by no means the case. There is, first of all, a small positive load due to driving a retainer of minimum weight and in perfect balance. This particular load will vary with the amount of oil in the bearing and the drag created thereby.

The serious loads, however, are those that may accrue from imperfections in the retainer and from conditions creating unbalanced forces of considerable magnitude. In operation the circumferential pitch of the

balls is continually changing, so that it is reasonable to suppose that the whole load of the retainer is taken at any one time on one of the little sleeve bearings. With the same bearing previously cited, the speed of the inner race at 3,600 r.p.m. is 37.3 ft. per second, therefore the speed of the retainer around the axis is about 18.65 ft. per second corresponding to a speed of 1,430 r.p.m. The actual retainer of one type of bearing of the proportions given weighs about four ounces, and while it is next to impossible with retainers as now made to make any definite statement regarding the bearing surface actually employed, a careful inspection of several bearings has led the writer to adopt a figure of 0.030 sq.in. per section as being a fair average. This figure is at least sufficiently accurate to use as a basis for the arguments intended to bring out.

The centrifugal force created by one pound suspended at the radius of 1½ in. rotated at 1,430 r.p.m., is 87 lb. Reverting to sleeve-bearing practice, let us assume a load of 30 lb. per sq.in. as being within safe limits. The unbalanced force, therefore, necessary to create 30 lb. per sq.in. on a surface of 0.030 in. is 0.0135 lb., or 5.4 per cent of the weight of the retainer proper. If the retainer is initially perfectly balanced, it must be kept concentric during operation, otherwise unbalanced forces are produced in proportion to the eccentricity of operation. Where an uneven number

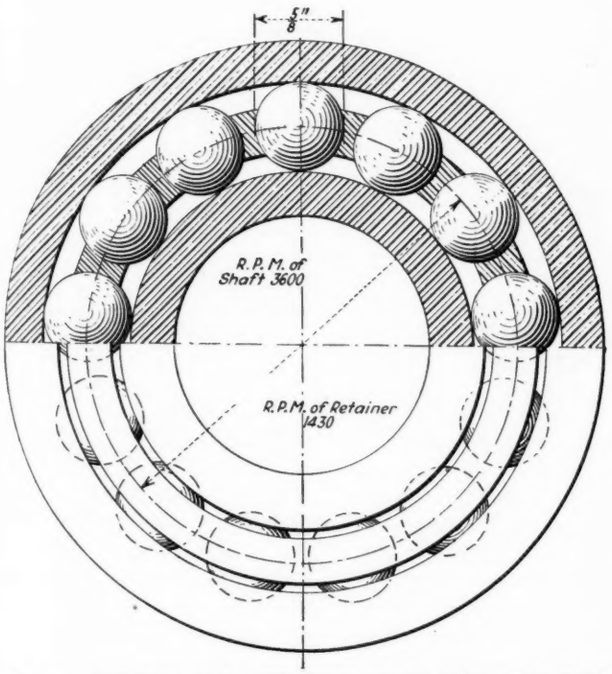


FIG. 3. TYPICAL BALL BEARING WITH RETAINER RING

of balls are used, the unbalanced forces due to eccentricity are accentuated.

Exception may be taken by ball-bearing makers to some of the figures used in the foregoing calculations, such as estimated bearing surface for example. The simple fact, however, remains that there is a practical limit at which ball bearings can actually be operated and, further, that this speed is considerably less than that published in the catalogs of ball-bearing makers and also considerably less than that derived from any of the existing formulas. When this practical limit is compared with that derived from a consideration of the balls in the races only, there is no relation between the two. There is, therefore, only one answer.

It is, of course, assumed in these arguments that rational engineering sense is used in the choice of the design of bearing, method of mounting, etc., and a proper grade of lubricant supplied.

A safe speed limit will be reached when the load between one ball and the adjacent bearing of the retainer is sufficient to break down the oil film at this point. This conclusion, then, brings to our attention the fact that the proper lubrication of such bearings is of much more importance than is generally believed. Ball-bearing manufacturers in general, in making recommendations as to the proper application of their product, almost entirely ignore this very important question. Moreover, the representatives and salesmen of such apparatus are responsible from time to time for making dangerously misleading statements as to the relative importance of this factor.

Considering the balls and races only, it has already been stated that no lubrication is necessary. Considering the balls in the retainer, we have a series of sleeve bearings the lubrication of which spells success or failure. This condition, therefore, calls for a retainer design that will permit the lubricant to enter properly the ingoing side of the bearing surface. In sleeve bearings it is just as important to lead the oil from the bearing as it is to the bearing. In like manner, then, a complete circulation through a ball bearing at high speed is essential. The general practice of partly filling a small chamber surrounding the bearing with oil prevents this important action.

There is no reason why ball bearings should not operate satisfactorily at high speed (say 3,000 to 4,000 r.p.m.) provided the foregoing considerations are properly taken into account, and experience extending over several hundred of such bearings has proved this contention. On the other hand, repeated failures with high-speed ball bearings has been in a great measure undoubtedly due to a lack of appreciation of the true internal workings of such bearings.

Extension of Power Contracts

An appellate court decision having an important bearing on power contracts which contain provisions for renewal for an additional term was handed down by the Montana Supreme Court in the case of Helena Light and Railway Co. vs. Northern Pacific Railway Co., 186 Pacific Reporter, 702.

The point in issue in this case was whether there had been a valid extension of a contract for the supply of electric current by plaintiff to defendant for use in operating pumps, etc. The original contract was to run for five years and provided that defendant should be entitled "to renew the same for an additional period of five years" on thirty days' notice in writing prior to expiration of the term of the original contract.

The court holds that giving of the written notice in proper time operated to extend the contract according to its original terms for an additional period of five years, without any action on the plaintiff's part and without the drawing up of a new agreement. But it is decided that the original contract was not renewed in the sense that before expiration of the additional term defendant could renew it for another additional term of five years. The provision for renewal must be interpreted as being limited to one renewal.

Operation and Adjustment of Turbine Machinery XIII—Prevention of Oil Throwing at Bearings

By EUSTIS H. THOMPSON
Consulting Engineer, Baltimore, Maryland

OIL throwing is caused by one or both of two things —air currents and oil leaks. Oil vapor is sucked into the windings of a generator, and in time a heavy deposit of oil is formed. On account of the proximity of the generator to its bearings, together with suction fans and heavy currents of air, there is a strong tendency for oil throwing.

Leakage of oil from the bearing is caused by: Stoppage of discharge pipe; oil groove in the bearing being cut too deeply through to the end of the liner; excessive clearance in the bearing; excessive oil pressure; porous castings; improper adjustment of oil deflectors, etc.; air leaks due to leaking joints of air passages in the vicinity of the trouble; excess air carried in with the oil; oil level too high.

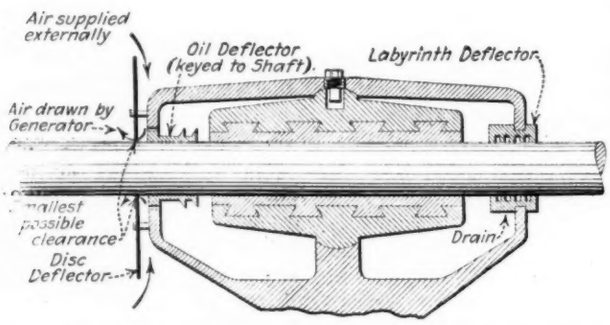


FIG. 1. DEFLECTORS PREVENT OIL BEING THROWN FROM THE BEARING HOUSING

If a bearing is mechanically correct but placed in such a position that air currents draw oil vapor from it the methods of prevention of oil throwing are as follows: Use of an oil deflector (Fig. 1) placed on the shaft inside bearing housing; labyrinth ring (Fig. 1) having close clearance to the shaft which is placed in the end of the bearing housing (this should have a drain where oil collected can be discharged); a ring of babbitt such as shown at the lower right, Fig. 2, with small clearance over shaft which, having a thread bored in it in such a direction that the rotation of the shaft will cause a draft in the bearing housing, may be put at the end of the housing; the suction fan (Fig. 2) is placed on the shaft just inside the housing, arranged to cause a current of air into the latter; a disc oil deflector (Fig. 1) placed outside of the bearing housing to prevent air suction acting on the end of it; an air-cell trap (Fig. 2) may be used for the same purpose; tight joints in the bearing; sometimes the use of a heavier grade of oil; breathers.

Figs. 1 and 2 show the use of these various devices on a bearing. In stopping oil throwing it is generally found that the disc deflector or air cell is the most convenient and effective remedy. With light air currents the reversed thread and suction fan and oil deflector are usually sufficient. Oil leaks should receive special attention. In locating oil leaks, particularly where oil vapor or particles of oil are carried by air currents, it is well to place strips of white paper in the path of the air currents; these will soon be spotted from the oil and by setting up such targets the path can be followed to the source of the trouble.

It sometimes happens that air passages, such as suction air paths for fans, are brought close to bearings. The joints of such casings often leak sufficiently so that the air sucked in will also carry oil vapor along and cause throwing. It is a good plan to make up such joints with heavy shellac and graphite. Targets, as described in the preceding paragraph, are useful in locating leaks when their sources cannot be readily found.

Some types of machines contain breathers placed on bearing housing (see Fig. 2). This is simply a pipe open to the atmosphere, which relieves the bearing housing of surplus air pressure caused by air being carried in with the oil and also allows oil vapor to be discharged where it can do no harm. These can sometimes be installed with good results and less expense than other methods of prevention.

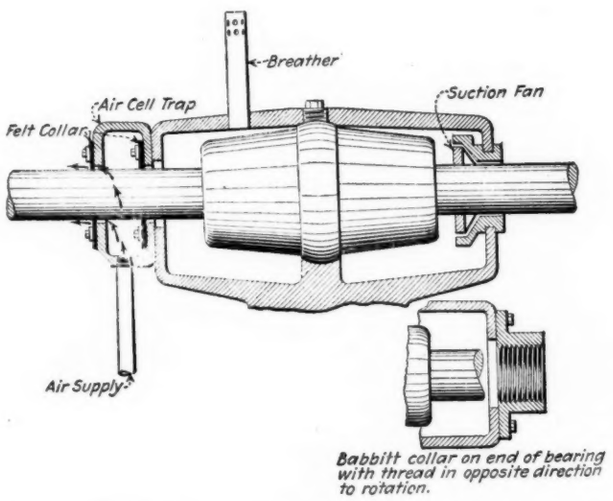


FIG. 2. OTHER MEANS TO PREVENT OIL BEING THROWN FROM BEARINGS

Refrain from mixing two different grades or makes of oil. This procedure often results in foaming, emulsifying or other defects in the quality of the oil.

Examine the oil strainer at regular intervals. This often reveals troubles, such as cutting of thrust bearings, main bearings or gears, which would not otherwise be noticeable. Preventive measures can therefore be taken before serious trouble results.

Correct oil, which produces the best results, is a matter that requires great care in determining. The advice of oil manufacturers and turbine manufacturers should be considered and the final determination made by careful trial. Every plant has special operating conditions. The behavior of the oil in actual operation, together with proper handling, is the best way to determine its value.

Oil-pressure gages frequently give trouble and wear out rapidly because of vibration of the oil piping and fluctuations in the oil pressure. A good way to avoid the vibration trouble to which piping is susceptible is to mount the gage on a pillow block, bedplate or other equally solid casting and then connect the gage to the pressure line by means of capillary tubing or ¼-in. copper pipe. Fluctuations of oil pressure can be partly eliminated by the usual method of throttling the valve placed below the gage.

In lubricating miscellaneous parts of a turbine a medium viscous oil usually gives best results on points of friction, such as valve gear, emergency trip gear, etc. This oil lasts longer and is not easily affected by high temperatures. Roller bearings or ball bearings which operate at low speed are also lubricated to best advantage with medium viscous oil or non-acid grease. High-speed bearings, such as governor-thrust bearings which contain ball races, should be supplied with a light grade of oil. Thrust bearings which contain no small balls when at high speed can be lubricated with heavy lubricants to advantage in cases of high temperature.

When using medium viscous oil or non-acid grease, make sure that the surplus or used lubricant does not find its way into the main oil system. Where a bearing requires a large supply of lubrication and drains into the main oil system the regular turbine oil should be used to prevent deterioration when mixing with the contents of the oiling system.

Graphite is furnished in many stages from pulverized dust to fairly large flakes. The finest and most impalpable grade is to be preferred for mixing with shellac.

Economic Value of Coal—I. A Comparison of Anthracite and Bituminous Coal

By B. S. MURPHY*

The author points out the necessity of adapting the plans to the particular fuel obtainable. Study is made of the available coals. Comparisons of coals of different heat values are brought out.

THE greatest single material item in the generation of power is the cost of fuel. The fuel is used to produce useful work by means of a heat transfer. Consequently the amount of heat that may be removed from the fuel and converted into useful work is the controlling item in the cost of power production. Of necessity the amount of heat that can be so removed must depend to a very great extent upon the heat available in the fuel itself, or on the calorific value, and also on the behavior of this fuel during the reaction period. This is equally true of all fuels, but the following discussion will be limited to coal, and more especially anthracite.

Relative Importance of Coal

In order to bring out the importance of the coal cost in power production Table I has been prepared, showing the relative power-station costs for a typical anthracite and a typical bituminous electric-power station for the whole year of 1910, the whole year of 1919 and the month of May, 1920.

TABLE I. MAKE-UP OF POWER COSTS

Station	—1910— A	1910 B	—1919— A	1919 B	May, 1920 A	May, 1920 B
Coal, per cent	42.0	77.2	58.5	64.8	62.0	65.2
Total operating material, per cent	48.2	80.9	60.5	69.6	64.0	69.0
Total operating labor, per cent	31.0	11.3	19.3	13.8	22.6	13.9
Total maintenance material, per cent	11.3	4.3	9.9	9.1	.....	10.5
Total maintenance labor, per cent	9.5	3.5	10.3	7.5	9.5	6.6
Total cost, per cent	100	100	100	100	100	100
Price of coal per ton, per cent	100	100	228.0	195.0	240.0	233.0

Net kilowatts of output for both stations—over 3,000,000 per month.

Both of these stations are in the same city; the station marked "A" burns anthracite and the other, "B", bituminous coal. In 1910 the "A" station was hand-fired and the operating labor cost, even with the low wages paid at that time, was 31 per cent against 10.3 per cent for the stoker plant with bituminous coal. In 1919 the "A" plant was stoker-fired with a poor grade of "A" coal, and the cost was 19.3 per cent for operating labor, with very much higher wages than in 1910, against 13.8 per cent for the bituminous plant. The last line of the table gives the relative cost of coal, with the average cost for 1910 taken as 100 per cent, to show the increase in coal cost, and indicates that in May of this year it was necessary to pay nearly two and one-half times as much for the coal with no prospects of any betterment.

From this it is safe to assume that over 60 per cent of the cost of power generation is coal alone. Assume that the output of a station averaged 6,000,000 kw. per month, and for the sake of an even figure assume that the cost of power was $0.0125 per kilowatt-hour of output, then the cost for the year for this station would be $900,000. If the relative cost of the coal was 60 per cent the coal alone would cost $540,000 for the year.

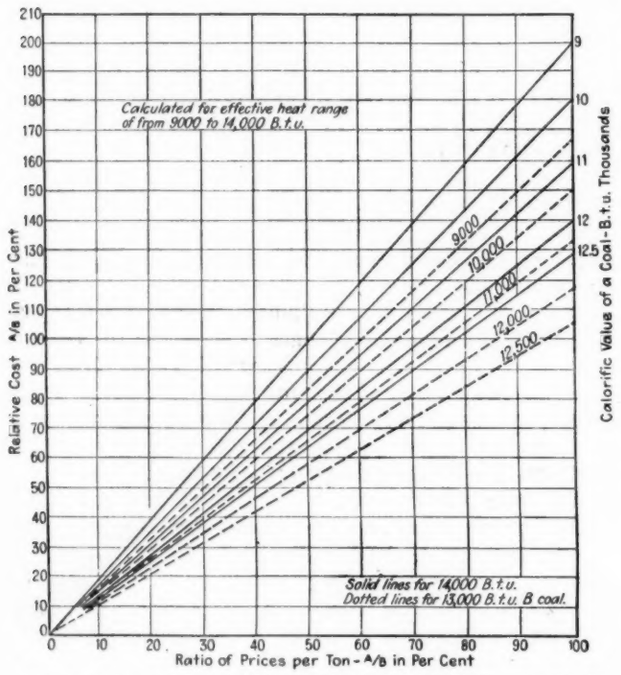
Relative Costs of Anthracite and Bituminous Coal

Another very interesting feature that this table brings out is that in 1910 the relative cost of anthracite as a fuel was low as well as the actual cost per ton as compared to bituminous coal, but since that time has increased in cost proportionately more than the "B" coal until in the early part of this year there was relatively little difference. This is due to the greater demand, the diminishing supply and the falling off in quality. In using anthracite it is, of course, necessary to figure a considerably greater quantity per kilowatt of plant output, but the true comparison is the economic one, the cost of producing this kilowatt irrespective of the number of pounds of coal required to be fired. This will take into account all the different phases, such as the cost of handling this additional bulk of coal, the disposing of more ashes and soot and, in the case of hand-fired installations, the additional firemen required.

*Superintendant of Power, Hudson & Manhattan R.R.

During the war this was very noticeable; the price and impurity content went up while the calorific value went down. This happened to both anthracite and bituminous, but not in the same proportion, for though the cost of the hard coal was perhaps only about half of that of soft, it was actually more expensive to use.

It is seen, then, that if 60 per cent or over of our total power-production cost is coal, too much study and attention cannot be given it. Fuel is becoming more costly and more difficult to procure each year, and the day has passed when a plant could be located at any desired place, boilers purchased, and the operation started and continued blindly with the understanding that "coal is coal." It is necessary now to pre-plan your


Calculated for effective heat range of from 9000 to 14,000 B.t.u.
Solid lines for 14,000 B.t.u.
Dotted lines for 13,000 B.t.u. B coal.
9,000
10,000
11,000
12,000
12,500
Relative Cost A/B in Per Cent
Ratio of Prices per Ton - A/B in Per Cent
Calorific Value of a Coal - B.t.u. Thousands

RELATIVE COSTS OF ANTHRACITE AND BITUMINOUS COAL

plant location to suit the available fuel supply for new installations, and for existing plants to adapt your facilities to what coal you can procure; for it is extremely difficult now to do the reverse, that is, grade your coal to suit original plant conditions.

In order to have a comprehensive knowledge of the coal analyses must be made, and the results of these analyses, in conjunction with known operating conditions, should be the governing factors in the selection of the coal if selection is possible, or in the adaptation of existing facilities to suit the coal available. These studies will soon show that the actual cost per ton at the mines or at the station will not necessarily be the controlling factor, for in certain cases the higher-priced coal may work out to the best advantage, while in another it will be the most expensive to use. In some instances a coal of high ash content may be made to give better results than one with less impurities if other conditions are available. And in some instances a low calorific-value coal may be made to give much better economy and operating results than one that ordinarily would be considered a much better coal from its chemical analysis.

It will be only a relatively short time until the small power station will be done away with completely excepting in cases where other factors, such as the utilization of waste heat, make it desirable to retain the plant. The practice of erecting the power station where the power is to be utilized will, for economic reasons, have to be abandoned, and the large distributing stations or super-power plants will be erected at the source of fuel and the power transmitted to the industries and centers of population. But in the meanwhile, for new projects or for existing plants, the first consideration is either the choice of fuel or the modification of existing facilities to suit the fuel available.

Investigation must first be made to see what coals are available in the quantities needed and what will presumably continue to be available for the next few years to come. In the East there is generally the choice of two kinds, anthracite and bituminous; so, if from a study of the coals available it is found that a continuous and ample supply of either can be anticipated, consideration must be given to the problem of which will best meet the requirements before going into the different grades of each.

To get the full benefits of any particular coal the whole boiler plant should be laid out with the requirements of this fuel in mind, for in the case of an existing station designed to use bituminous considerable changes would necessary to convert it to use anthracite. This conversion would be costly, depending on the size and other operating features of the station, so of course the interest charges on the necessary expenditure to make such changes would have to be considered against any gain anticipated by the changing of the fuel. In new projects the difference between the first costs of the layouts would in turn have to be considered in the same manner.

A Hypothetical Case

To bring out these elements more forcefully a hypothetical station will be assumed and a comparison made of the fuel. Assume that it is reasonable to expect an adequate supply of either "A" or "B" coal and that the purchase price of 2,240 lb. delivered at the boiler room is: Anthracite, $5—11,100 B.t.u. as received; bituminous, $9—14,000 B.t.u. as received. A comparison of costs should next be made based on the total heat content in the coals; this appears in Table II.

TABLE II. ANTHRACITE AND BITUMINOUS
(Comparison on total heat basis)

	Anthracite	Bituminous
Cost per pound, dollars	0.00223	0.00402
Pounds of coal to make 14,000 B.t.u.	1.26	1.00
Cost for 14,000 B.t.u., dollars	0.00281	0.00402

From this it would appear that with the price assumed we could expect to procure the same heat in the firebox with anthracite at a cost but 70 per cent of that for bituminous. However, this is not a true comparison on account of the ash, burning quality, etc., as will be more fully gone into later, but may be considered the very maximum difference that would exist between the use of the two coals.

In a later article it will be shown that the more correct way of approaching this subject is by a comparison of the useful range of heat and not by the total heat in the coal. For instance, when the freight charges on the anthracite are in the neighborhood of 40 per cent of the total cost of the fuel we must set a low limit for our heat content and say that it does not pay us to purchase coal with less than 9,000

B.t.u.; then the useful range would be between 9,000 and 14,000 B.t.u. or 5,000 B.t.u. The "A" coal containing 11,100 B.t.u. is 2,900 B.t.u. less than the "B" and lacks 58 per cent of the heat necessary. There would be required 1.58 times more coal for an equal heat content, or the cost would be $0.00352 for 14,000 B.t.u., or 88 per cent of the cost for an equal heat content in the "B" coal. This method is more nearly correct than a comparison of the total heat in the coal and will represent the maximum cost for the hard coal. It is only necessary to compare "A" and "B" coal of two different heat values to establish a curve which will determine the deficiency of heat for any coal. If we refer to Table I for 1919 we find the ratio of the coal cost is 90 per cent, while for May, 1920, it was 95 per cent, showing that the effective range method is not far out as other plant conditions, such as economy of prime movers, etc., will make up this difference.

Relative Values of Different Coals

On the chart are plotted curves to show the relative values existing between bituminous and anthracite coals of different calorific values and different prices per ton, based on the effective heat range of 9,000 B.t.u. to 14,000 B.t.u. The horizontal scale is the ratio of cost per ton of the two coals, or the cost per ton of the hard coal divided by the cost per ton of the soft multiplied by 100. The vertical scale is the relative cost of the anthracite in per cent, the bituminous taken as standard, or 100 per cent. The solid lines give this ratio when the calorific value of the soft coal is assumed to remain constant at 14,000 B.t.u., and the calorific value of the hard coal varies as shown from a minimum of 9,000 B.t.u. to a maximum of 12,500 B.t.u. The dotted lines also give the relative ratios between the coals when the calorific value of the soft coal is constant at 13,000 B.t.u. For intermediate ratios, for coals of other calorific values than those given, we interpolate between the lines. For instance, if in our choice of coals we could anticipate a hard coal of 12,000 B.t.u. and a soft coal of 14,000 B.t.u. we can pay up to 73 per cent of the cost of the latter for the former. Or if the "B" coal was available at $8 per ton we could not afford to pay more than $5.94 per ton for anthracite; while if there was available another anthracite of, say, 11,000 B.t.u., we could pay only 63 per cent, or $5.04 per ton for it. On the other hand, if the soft coal contained only 13,000 B.t.u. and we still had to pay $8 for it we could use 11,000 B.t.u. anthracite and pay at the rate of $6.08 per ton. All of this is with the understanding that the coal is a fit one from an operating standpoint to meet the conditions under which the boilers are to be operated, for the calorific value is not the only controlling feature by any means. But this shows that but little dependence may be placed on the actual price per ton for any coal when this item is taken by itself as a comparative feature.

TABLE III. VARIATION IN RELATIVE COAL COSTS

Year	Bituminous Coal, Per Cent	Anthracite Coal, Per Cent
1911	100	77.8
1914	100	78.0
1919	100	119.0

It is is seen that the quality of the coal will have a great bearing on this subject in connection with the relative price. For instance, during the war the quality of all coal fell off and the price increased, but the anthracite suffered more in this respect than the bituminous. Basing the comparison of the effective range as above for one anthracite station the relative value comparisons were as given in Table III.

This showed that from 1911 to 1914 a saving in cost of fuel of about 22 per cent could be expected by the use of anthracite. This saving was cut down after 1914 gradually until in 1919 the hard coal was actually 19 per cent more expensive to use than the soft. This was due to a very serious falling off in the quality and a proportionately greater increase in the price per ton, but fortunately this condition is righting itself in that the coal is of somewhat better quality and also that the "B" coal has increased in cost per ton to a greater extent than the other, or rather the increase was slower for the bituminous and came along at a later date.

We will now return to our original assumption of an output of 6,000,000 kw. per month, and with the "B" coal a unit cost of power of $0.0125 and a total coal cost of $540,000. If we take the saving by the use of anthracite as 12 per cent based on a cost of $0.00352 for 14,000 B.t.u. of anthracite and $0.00402 for 14,000 B.t.u. of bituminous coal, this would represent $64,700 per annum, or the interest at 7 per cent on $925,000. Therefore, for a new station it would pay to put in considerable additional equipment, or in an old station, by extra blowers, changes to stokers, etc., to use this cheaper fuel, provided there was an assurance that the supply would be adequate, of the required quality and that there would not be a greater percentage increase in cost than the soft coal for, say, the economic life of the station, or fifteen years.

What Caused the Boiler Heads to Corrode?

An article describing the failure of the rear steam drum of a water-tube boiler at Newmarket, Ont., Canada, was published in *Power* July 8, 1919. The

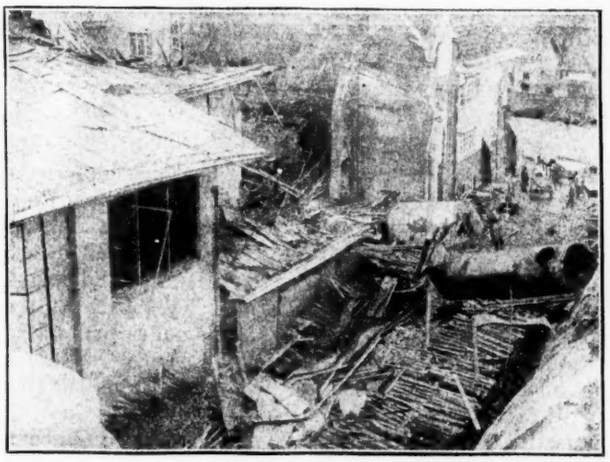


FIG. 1. WHERE A PORTION OF THE EXPLODED BOILER LANDED

head of this boiler was in a weakened condition, the failure following the line of rivet holes below the water line and tearing through the solid metal well up in the bumped portion above the water line. The evidence was that the metal was brittle along the line of rivets. It was suggested that the explosion might have been caused by caustic soda which might have attacked the

metal, the liberated oxygen in turn affecting the properties of the metal and producing brittleness.

Attention has again been turned to the possible action of caustic soda by the recent report of an investigation regarding a disastrous boiler explosion last May at the municipal power house at Turku, Finland.

The boiler room of the power plant originally contained two Steinmuller water-tube boilers, each with a heating surface of 208 sq.m. (2,239 sq.ft.). In 1910 another Steinmuller boiler of 429 sq.m. (4,618 sq.ft.) heating surface was installed and a Babcock & Wilcox

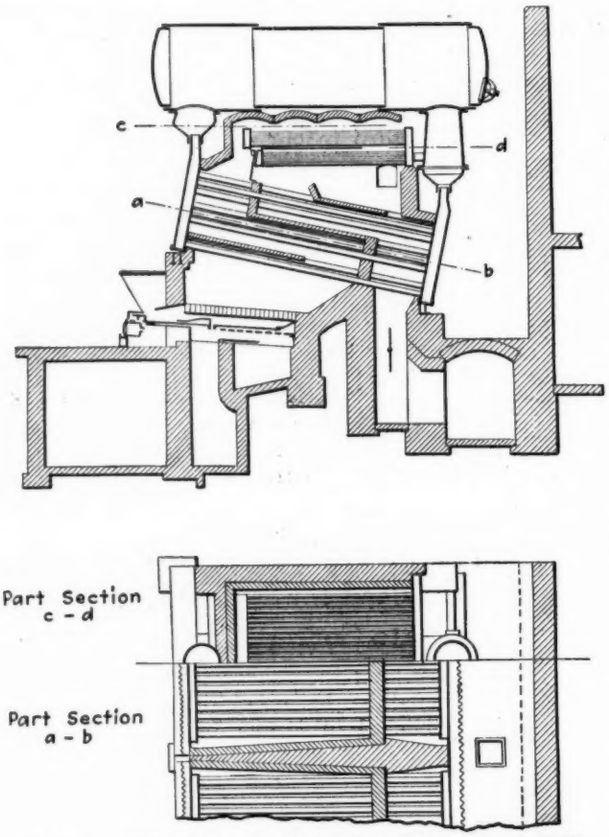


FIG. 2. SECTIONAL PLAN AND ELEVATION OF THE EXPLODED BOILER

unit of 500 sq.m. (5,382 sq.ft.) heating surface in 1914. All four boilers were operated at a working pressure of 13 atmosphere (191 lb.) and were furnished with superheaters. In addition there was an economizer. The boilers were fed by four piston pumps, and in the forward end of the room there was an apparatus for purifying the feed water. No. 1 Steinmuller boiler was responsible for the explosion. The cylindrical drum was thrown over against a ledge. The front water leg was partly fastened to the drum, but the water leg and the connection between that and the drum were found about 25 meters (82 ft.) from the boiler house on the roof of an adjoining engine room. The rear head of the drum had been entirely torn off. The front head worked inward, loosening the joints. The tubes loosened from the superheater, and boiler No. 2 was moved about one meter (3.28 ft.) back from its foundation. The other boilers were evidently undamaged except for small breaks in the joints and setting.

No. 1 boiler had been inspected at regular intervals by a Government inspector, the last time being three years ago, when no flaw was found. Every time the boiler was cleaned the engineer at the plant went over the tubes and shell on the outside to see that everything was in good condition. Three weeks before the explosion occurred the engineer of the plant had the boiler cleaned and it was inspected as usual. At the same time a test was made at a pressure of 20 atmospheres (294 lb.), the plates showing no signs of weakness. Under the present boiler rules a test pressure of 20½ atmospheres (301 lb.) is necessary for a boiler to be run at 13 atmospheres (191 lb.); therefore the pressure was not exceeded in the test. At the time of the accident the gages showed a pressure of 11 atmospheres (162 pounds).

In the past the feed water was never found to contain anything that might cause the corrosion of the plates.

A careful inspection was made of the pieces of the exploded boiler. The loosened rear head and the shell of the drum were examined to ascertain the depth of any possible corrosion, and it was found that on the lower half of the shell, below the water line, the plate had been eaten so deep that only about two or three mm. (0.08 or 0.12 in.) of pure metal was left. The corrosion had started exactly at the water line on both sides of the shells and heads. When the front head was inspected it was seen that below the water line a similar corrosion had taken place as in the rear head.

It was at first thought that the corrosion of the heads was due to some chemical contained in the feed water, which had reacted with the metal. But on the other hand it was noticed that the corrosion took place only below the water line and all other parts of the boiler were clean and without flaw. It also seemed impossible that electrolysis could have caused the corrosion of the plate. It was hinted that there might possibly have been some flaw in the workmanship of the shell, but the plate had given way below the water line and there was no sign of tearing in the steam part of the drum. Fig. 2 shows the large diameter of the drum and the comparatively small dishing in the heads, and the small radius at the upturn of the flange.

Why the corrosion took place only below the water line remains a mystery. A chemical test of the water and plate might show, if it were possible, that while the plate was under a strain such as would take place with varying pressure, the corrosion had been more rapid. Believing that a like condition might exist in other units the second Steinmuller boiler was opened up and a slight corrosion was found to have taken place, similar to that in the exploded boiler. The corrosion here was not nearly so wide, but it could be easily seen if its presence was looked for.

Boiler No. 3 had not started to corrode, but the color of the plate had changed suspiciously at a point just below the water line. The Babcock & Wilcox boiler showed no signs of corrosion.

Any semi-Diesel oil engine should have a lubricating-oil consumption not to exceed one gallon per 500 horsepower hours. The oil taken from the crankcase is a mixture of lubricating and fuel oil. It seldom can be used on the engine again, but will do for lineshaft bearings. If a heavy-bodied oil is purchased and the engine refuses to burn it, mixing with kerosene will eliminate the trouble, although the bulb will carbonize. The kerosene tends to separate from the crude if it stands any length of time.

Checking Direct-Current Switchboard Shunt Ammeters

By H. C. Yeaton

It often becomes necessary to check a direct-current switchboard ammeter used with a shunt, in order to ascertain its accuracy. Ammeter shunts are constructed so that there is a certain voltage drop across their terminals when the full current at which they are rated is flowing through them. Direct-current switchboard ammeters are connected to the terminals on the shunt by means of leads. These leads are not interchangeable, as they are of a certain resistance and they are calibrated together with the shunt and ammeter. Any change in the resistance of the leads will affect the accuracy of the measurement.

On the switchboard ammeter the scale is usually marked in primary amperes; that is, the actual amperes flowing in the line. The voltage drop across the shunt is proportional to the current that is flowing, and the switchboard instrument is calibrated so as to indicate full scale when the rated current is flowing through the shunt.

There is usually a voltage drop across a switchboard shunt of approximately 50 or 60 millivolts when the rated current is flowing; therefore, ammeters are usually calibrated with 50 or 60 millivolts impressed across the ends of the leads, for full scale deflection. If there is any doubt about the shunt drop, it is advisable to write to the manufacturer for information.

A switchboard ammeter, which is used with a shunt, is usually checked with a portable millivoltmeter and is connected as shown in Fig. 1. As heretofore stated, the voltage drop across the terminals on the shunt is proportional to the amount of current flowing, and as the scale of the switchboard ammeter is proportional to the voltage drop across the shunt, it is obvious that by

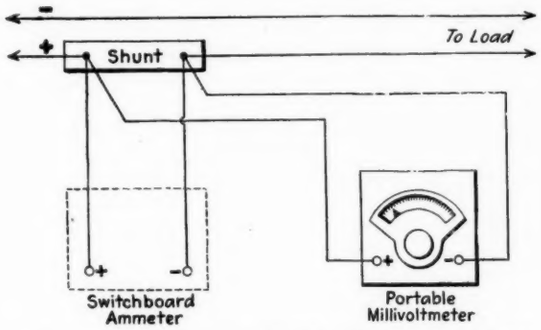


FIG. 1. CHECKING AMMETER WITH PLANT LOAD

checking the shunt drop with a portable millivoltmeter, the accuracy of the switchboard instrument may be determined.

Suppose that the shunt shown in Fig. 1 is rated at 100-amperes, 60-millivolts, and the switchboard ammeter used with the shunt has a scale of 100 amperes. To check the ammeter, connect a portable millivoltmeter of at least 60 millivolts range across the terminals of the shunt as in Fig. 1. The correct leads should be used with the millivoltmeter; that is, the leads which the instrument was calibrated with and which were furnished with it by the manufacturer; otherwise the readings will be in error.

Now suppose that the ammeter indicates 75 amperes. Then, since the drop across the shunt is proportional to the current, the millivoltmeter will read, if the ammeter reading is correct, (*Ammeter reading, in this case 75,* times *drop across shunt at rated load)* divided by *full scale rating of ammeter,* or in this problem, $(75 \times 60) \div 100 = 45$ millivolts. If the ammeter reading is in error, the correct amperes may be calculated from the millivoltmeter reading. Suppose in the foregoing the millivoltmeter showed a reading of 48. Then since the reading of the ammeter is proportional to the drop across the shunt its reading should equal (*millivolt drop across the shunt* times *full scale rating of the ammeter*) divided by *drop across shunt at*

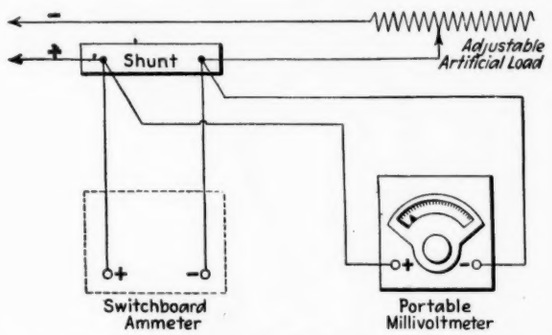


FIG. 2. CHECKING AMMETER WITH ARTIFICIAL LOAD

rated load, or in this problem the ammeter reading should be $(48 \times 100) \div 60 = 80$ amperes. However, if the ammeter indicates only 75, it is reading 5 amperes low. When checking the instrument with the normal load on the circuit, it may be found difficult to take readings at periods when the load remains constant for any length of time, but by taking the readings of the two instruments simultaneously, accurate results can be obtained. As the load on the circuit varies during the day, several points on the ammeter's scale may be checked for accuracy.

Fig. 2 shows the connections with an adjustable artificial load connected in the circuit, so that by varying the load any point on the ammeter's scale can be checked. If it is required to check the points at 20, 40, 60, 80 and 100 amperes, the voltage drop across the shunt would be proportional to the scale readings on the switchboard ammeter, and the following calibrating table is obtained by taking readings and making calculations as indicated in the foregoing:

Switchboard Ammeter Reading	Millivolt Drop Across Shunt	Portable Millivoltmeter Reading
20	12	12
40	24	24
60	36	36
80	48	48
100	60	60

Other points on the ammeter can be checked in like manner, but four or five should be sufficient to determine the accuracy of a switchboard instrument.

Bolivia in its present stage of development is a country of mines, though other resources exist. There are only three or four towns of any importance and population, and the present field for street-railroad and power-transmission material is restricted. The greatest hydro-electric resources are those in the vicinity of La Paz, Tres Cruces and Colquechaca, and plans for their exploitation have been made. The three initial power plants will entail an expenditure of $10,000,000 and will require large quantities of other machinery and electrical accessories in addition.

Making a Difficult but Rapid Repair to an Ammonia Pump

BY D. L. FAGNAN

Our 7 x 3 x 10-in. aqua ammonia pump, a sectional view of which is shown in Fig. 1, had been gradually failing of late, and although new hard-rubber valves had been installed and the piston rings found in good condition, the writer at last located the trouble in the valve seats. A section through the valve chamber is shown in Fig. 2. The suction-valve seats were scored

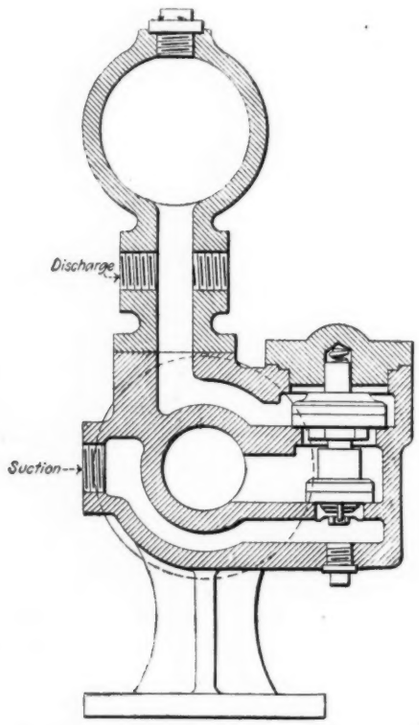


FIG. 1. END SECTION OF THE PUMP, SHOWING VALVES

to a depth of 0.003 in. in several places; that is, practically eroded away in narrow ridges. The discharge-valve seats were found to be in decidedly worse condition.

We immediately communicated with the pump builders, advising them of the conditions and asking them to furnish a valve-seat refacer or other machine for the work. But they had nothing of the kind and suggested that the ammonia end of the pump be brought to their shops where they would reface the seat in the lathe. But as the pump is needed in the plant every day in the year excepting in zero weather, dismantling was out of the question, and we so advised them. Near-by we could find nothing that would allow of properly centering the cutters, as the top of the pump was found to have no studs but instead was fitted with only a large screwed cover.

It occurred to us that the valves themselves could be used to regrind the seats true. We went to the pump builders and got in touch with the foreman of their shops, an excellent mechanic, and together we evolved a plan.

A full set of blank castings of the suction and discharge valves were on hand, and we planned to make them as shown in Figs. 3 and 4. Fig. 5 shows the rods as made to use as a ratchet brace. Fig. 6 shows the emery and carborundum cloths as cut into rings. A ream of each number was ordered, and by using a wooden templet and marking the circles on the smooth side of cloth with pencil, the templets were readily shifted to obtain the greatest number of circles possible from each sheet to avoid waste. A pair of shears were used to cut the larger circles, and a cast-iron flange containing ⅝-in. holes and a ball-peen hammer to cut the holes through the center for capscrew openings.

We then had the pump drained and ventilated. Next we attached the discs of cloth between the cast-iron disc 2 and valve 1. The 9-in. rod is attached to the suction-valve casting. A few drops of oil was put on the emery cloth, which was rotated back and forth 50 or 60 times on the seat. The coarsest cloths were used first until a fairly good seat was made, then cloths of fine grade down to No. 0 were used. After an hour's work on

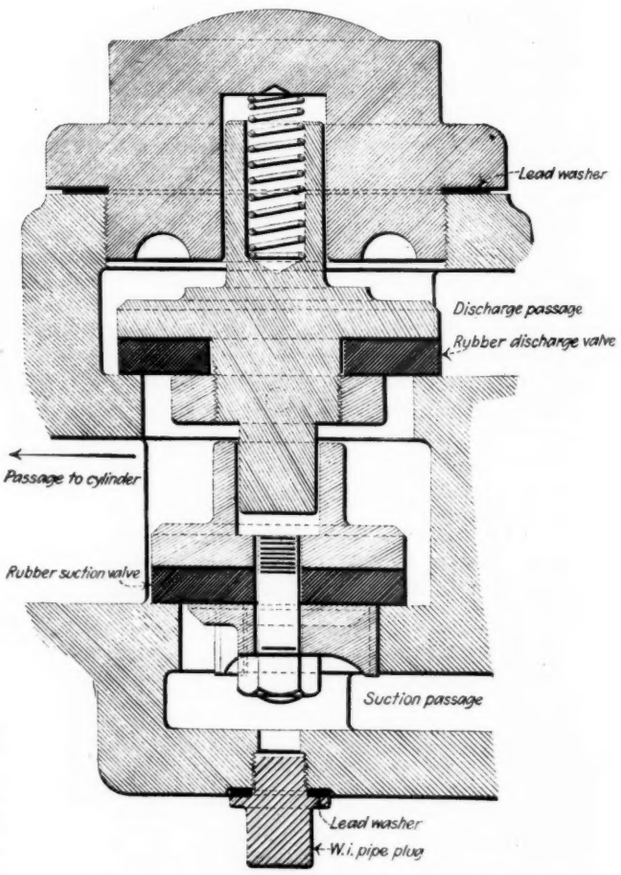


FIG. 2. SECTION THROUGH VALVE CHAMBER OF THE PUMP

each of the suction valve seats, an excellently polished and true seat was obtained. Notice that the opening in the bottom of the discharge valve seat is 3 in. and valve seat 4 in. By using a 3-in. disc to clamp the emery cloth, the disc forms a well-fitting guide for the discharge valve.

No tilting or canting can possibly occur; therefore, a true seat is obtained by grinding if reasonable care is observed in using the brace. Also the hole in the suction-valve seat is 2 in. and the valve 3 in.,

therefore a 2-in. disc was used as a clamp for the suction valve, and in this case also no canting occurred. The discharge valves took longer, 3½ hours on each one, but an excellent seat was obtained on each. Then the disks. That is, they were respectively 3 in. minus 0.004 in. in diameter, 2 in. minus 0.004 in. in diameter; holes for the guides were reamed true to size. The emery cloth for making the discs cost five dollars.

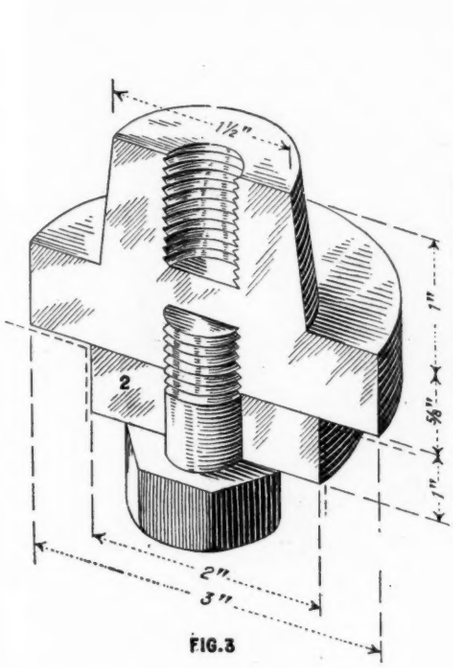


FIG. 3

SUCTION VALVE CASTING MACHINED FOR REGRINDING SEAT

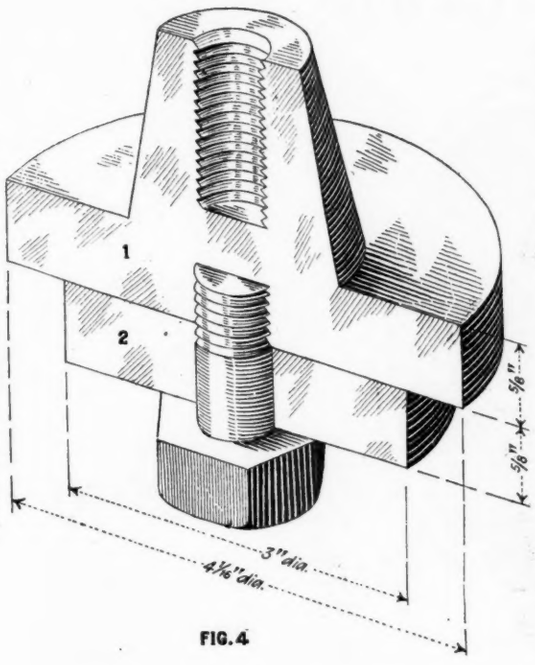


FIG. 4

DISCHARGE VALVE CASTING MACHINED FOR REGRINDING SEAT

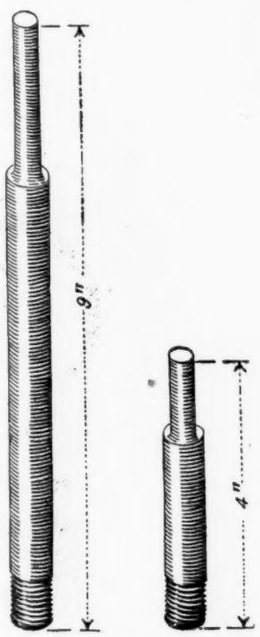


FIG. 5

RODS TURNED DOWN TO USE RATCHET BRACE

seats and passages were thoroughly cleaned, using a magnet made from an old file and cloths to get out all grit. The hard-rubber valves were then ground on their seats with emery and oil until they seated like new.

When a vacuum was needed on an absorber, it was almost impossible to get a good one before repairing the pump. The pump slip was excessive. When the pump was idle the leakage back through the exchanger

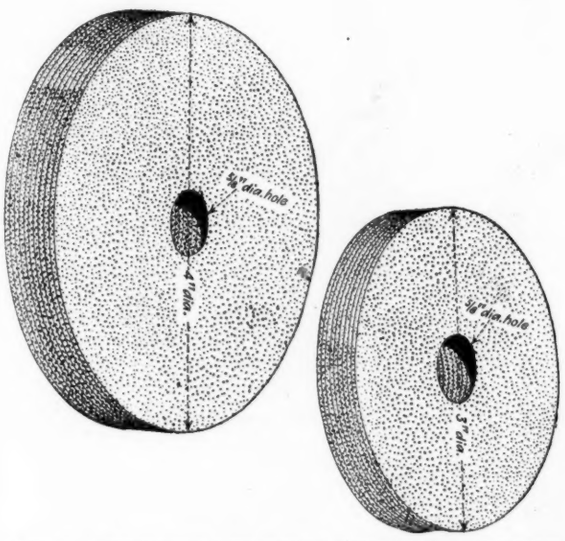


FIG. 6. EMERY CLOTH DISCS USED FOR DRESSING VALVE SEATS

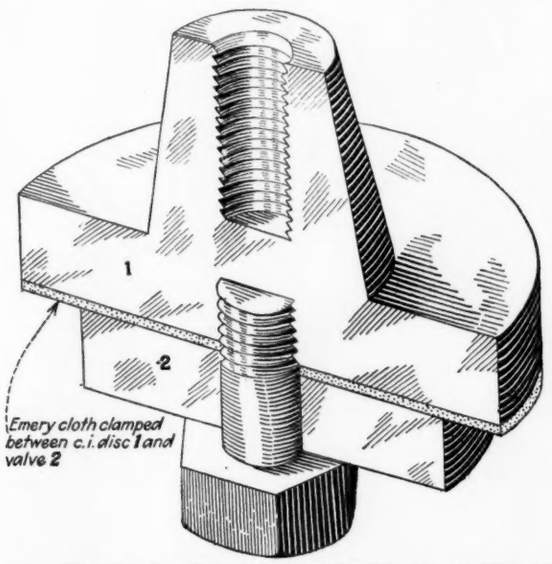


FIG. 7. SHOWING APPLICATION OF EMERY CLOTH DISC BETWEEN VALVE DISC AND SEAT

The pump ran fine after the valves had been ground. The outlay in money to do the job was $12. This included machining, the blank valve castings and making the rods, supplying capscrews, etc., with disc machined both sides, allowing about 0.004 in. clearance on the from the generator worked back into the aqua receiver and through it into the absorbers, causing a considerable rise in pressure and making the pump gasbound. Now, with tight valves and seats, all this trouble is eliminated.

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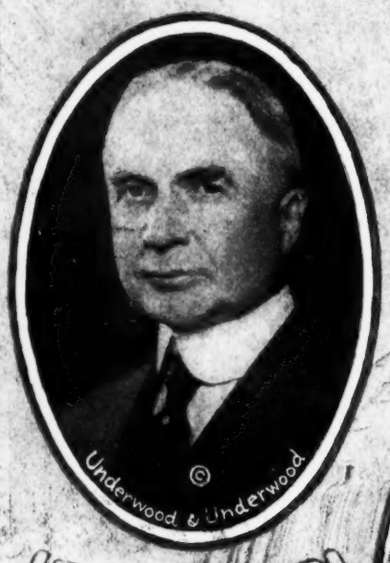

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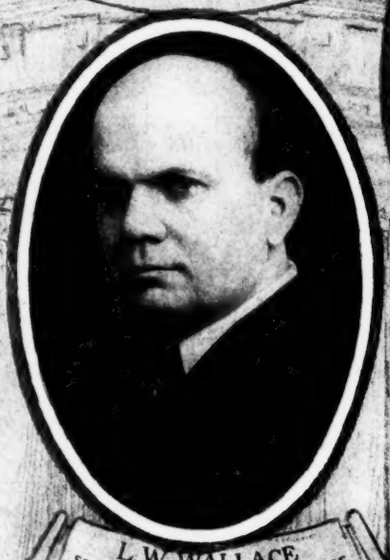

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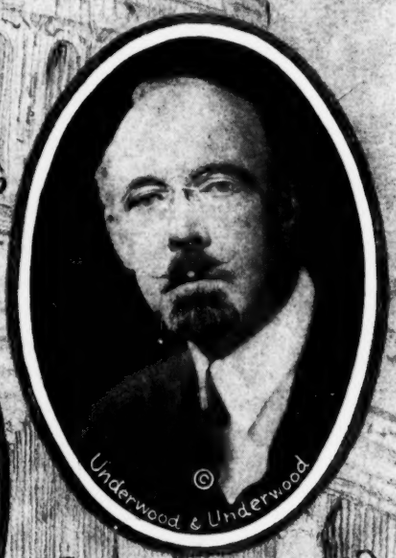

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EDITORIALS

Advancement in Central Station Boiler Design

IT IS but a few years ago that a five-hundred horsepower boiler was considered of large capacity; now it is looked upon as a small unit. Likewise a pressure of one hundred and twenty-five pounds was considered high; now one hundred and seventy-five pounds is common practice, three hundred pounds is fast becoming so, and recently boilers have been installed that were designed for three hundred and fifty pounds working pressure. Such a boiler would be fifty-one sections wide, each of four hundred and fifty-two square feet of heating surface. Formerly five thousand square feet of heating surface represented the large units; today boilers are being designed with twenty-three thousand and fifty square feet of heating surface. Allowing ten square feet per boiler horsepower, these boilers will have a normal rating of two thousand three hundred and five horsepower.

On another page of this issue it is shown that builders are ready to manufacture units of these large capacities to carry high pressure and high superheat. These double-decked boilers permit of increased total heat absorption through direct radiation, the six rows of tubes of the lower deck being exposed without baffles to the radiant heat of the furnace.

By locating the superheater immediately above the lower deck of the boiler tube, the desired degree of superheat may be obtained with a minimum amount of superheater surface, consequently a corresponding minimum superheater cost.

Naturally, such sizes of boilers will be equipped with duplex furnaces and a furnace volume supplied of approximately three and ninety-five hundredths cubic feet per rated horsepower.

Such boilers clearly show the trend as regards modern power-station practice. Large units and higher pressures are necessary to meet the increase in the load factors of the present-day central station.

Conservative Guarantees

IT IS not necessary to make impossible guarantees to sell goods. A conservative guarantee, whether of efficiency or capacity, will carry more weight and have more respect shown for it than will wild, irresponsible claims of impossible figures such as sometimes are made by over-enthusiastic salesmen. Power-plant apparatus is not always sold by engineers, but sometimes by men who are primarily salesmen and who are sent out to get the business. If it becomes necessary in keen competition to outbid someone else in efficiency or capacity they will do it and take a chance on the results. Coal salesmen sometimes bid on contracts, making B.t.u. guarantees that they know cannot be met, the bid being accompanied by a schedule of penalties for coal that does not come up to the specifications. This is simply another way of cutting the price and gets by in the coal business.

When selling power-plant apparatus, however, it is a more serious matter. Large amounts of capital are invested in boilers, generators and other equipment on certain guarantees. If these guarantees are not met when the installation is completed it is an expensive and unsatisfactory process to alter the apparatus to make good, and usually it is not satisfactory to make an adjustment in the price to meet the conditions. Boilers, for instance, are installed in many places where floor space is at a premium and it is necessary to get the greatest steam capacity possible in this space. Simply deducting a percentage of the purchase price, if such capacity is not realized on test, does not meet the situation, because throughout its life the plant is penalized by a lower capacity per unit of floor space than was originally intended when the installation was laid out. The same reasoning applies to efficiency guarantees for an engine, turbine or other power-plant machinery. The penalty that it would be possible to inflict will never cover the loss that will be continuous throughout the life of the equipment.

It is much better to quote conservative guarantees that are rather certain of being exceeded. Purchasers who know anything about power-plant affairs will have more confidence in a firm following this practice, and in the long run both seller and buyer will be better served.

Speculation in Anthracite

ALTHOUGH conditions in the bituminous markets have recently shown improvement the anthracite industry is still a pawn in the hands of the speculator, with retail prices outrageously high, in spite of a slight drop during the past few days, evidently as a result of the constant agitation that has been going on.

The anthracite industry, unlike the bituminous, is not a competitive field and from seventy to seventy-five per cent of the output is in the hands of a few large operators who claim to be selling at a normal profit and are listing their prices. They claim further that the high retail price is due to the independents taking advantage of the shortage resulting from the strike which occurred in September.

The local dealer, on the other hand, claims his selling price is arrived at by pooling his costs and that the high average is due to having to purchase the bulk of his coal from the independents.

If the bulk of the anthracite produced is being sold by the large operators at the listed prices, then why is the local dealer not able to secure the bulk of his supply at these prices? Either this coal is first passing through the hands of the speculator or the dealers are hoodwinking the public.

It is incredible that the large operators are unknowingly diverting their production to the speculator, and the statement by Senator Calder that there has been connivance between some of the operators and these speculative middlemen seems suspiciously true in spite of the many denials.

Again, why is it that some of the large wholesalers, while professing a desire to assist in a reduction in price to the consumer, invariably invoke the legal machinery of the courts whenever the investigating authorities endeavor to gain access to their books. It must be most disheartening to the prosecuting officers to constantly have their efforts thwarted by the technicalities of the law.

A ray of hope lies in the threat by Senators Calder and Edge, of the Senate Coal Investigating Committee, to introduce at the new session of Congress, a bill that will put teeth into the law and minimize the opportunity for speculation in coal. Until then we must expect anthracite prices to run riot, unless, indeed, the prospect of Governmental supervision has a steadying effect on the industry before that time.

Germany and the United States Making the Same Experiment

ON ANOTHER page appears a report from our Berlin correspondent on the coal situation in Germany. An interesting feature of this report is the proposal of Stinnes, the principal German "coal baron," to form trusts of related industries, in which procuring of the raw material, its manufacture into a finished product and the production of power used in the process will be under one organization. There is now a very similar proposition under way in this country; the plan is being tried at the River Rouge plant of Henry Ford. Mr. Ford already mines his own coal and transports it to his plant, and it is his further intention to bring iron ore to this new plant and produce all his own steel and iron as well as power.

This fits closely the description of Stinnes' plan, except for the representation of consumers on a governing board. The latter provision, however, savors more of bait than of an integral part of the astute German's proposal. It should be interesting to watch the progress of the movement in the two countries and to make comparisons of results. It should be of especial interest, because nearer home, to watch Henry Ford's venture; it is a radical step not only in engineering, but in economics as well.

It is hard to conceive of an enterprise sponsored by Mr. Ford becoming oppressive to other business, for his effort has always been to help the other fellow rather than to fight him. But suppose his plan works out well and is adopted by others? Would its tendency be good, and would it, perhaps, afford a solution of our difficulties? Or would it be perverted—would it give the profiteer a tighter grip on the throat of industry than he has today?

Cinders in Stack Gases

CINDERS as applied to stationary power-plant engineering have been of little importance except in a few instances where low-grade anthracite has been burned at high rates of combustion with forced draft. In such cases elaborate means have been taken to reduce the discharge of solid material from the stack, the problem being complicated by the presence of sulphur in the gases of combustion and the desire to keep the temperature as high as possible for the sake of good operating conditions.

Although they have a definite fuel value, cinders represent a small loss, and they are not so much of a nuisance as smoke or soot, as they do not form an insulating covering on the heating surface of the boiler and do not have the damaging action familiar to a smoky atmosphere. However, when taken to mean any of the non-gaseous products of combustion which are discharged from the stack, the term takes on new importance. Many plants operating without smoke are discharging into the atmosphere a considerable amount of finely divided material which can be classed as combustion dust. When viewed under a microscope, much of this material is seen to have the characteristics of true cinders, consisting of a considerable amount of combustible material mixed with fused silica, ash, slag, etcetera. This substance, although spread over a great area, finally reaches the ground and in industrial communities represents annually hundreds of tons of precipitate per acre.

Two influences are now at work that will bring the cinder question more prominently to the front. The first is the growing insistence on burning the lowest grades of anthracite, introducing, as it does, forced draft; the second is the increasing use of powdered coal in the boiler room.

Theoretically at least, powdered coal will find its best application in burning the high-ash low-grade coals, and this emphasizes the question of disposal of the solid products of combustion. While there is a small amount of combustible material in the cinder, there is a large proportion of objectionable matter which it will be advisable to eliminate if possible. Luckily, the draft necessary in the burning of powdered coal is low. This condition lends itself to the introduction of deflectors, dust catchers, cyclone separators or other devices that may help to solve this problem.

Marine Oil-Engine Situation

IT IS customary to expect engineers to be ever ready to adopt improved machinery. In view of the intense interest displayed by the lay public in the matter of the merchant marine and the oil engine, it is somewhat surprising that no paper on this or kindred subjects was presented at the annual meeting of the Society of Naval Architects and Marine Engineers in New York City in November.

The motor ship is here to stay, and the naval architects can do much to encourage the general adoption of this economical power. The problem of adapting the Diesel to marine service is by no means so difficult of solution as was that of the steam turbine, neither are the operating difficulties of such magnitude; while the economies that can be secured by the oil engine are so great that the naval architects and engineers will do well to give considerable study to this important subject.

In reply to his message of congratulation to James Harkness, past president of the society, just elected governor of Vermont, Secretary Rice of the American Society of Mechanical Engineers has received the following:

Delighted to receive your message of congratulations. Tell my fellow engineers who are looking over the sea of politics to come on in. The water's fine!

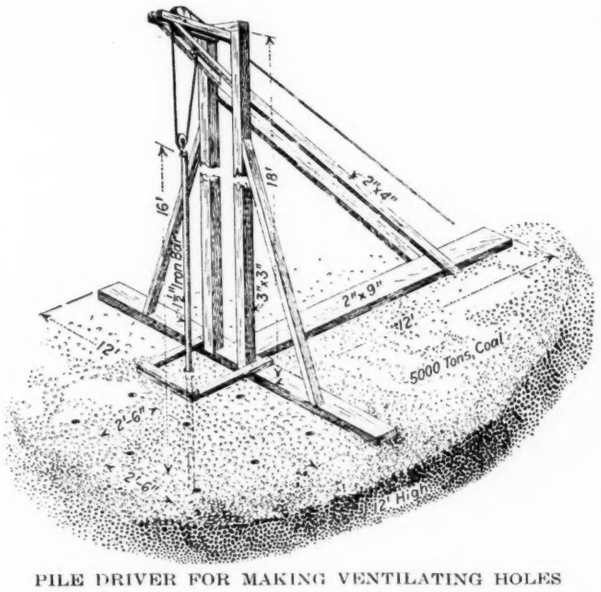
JAMES HARTNESS.

If more engineers would take a similar plunge, it would be good for politics.

CORRESPONDENCE

Ventilation of Coal in Storage

I read with interest the article on page 618 of the Oct. 19 issue of *Power* on "Ventilation of Coal in Storage." When I took charge of my present plant, seven years ago, I found a coal-storage fire in full blast and we lost considerable fuel. Coal is received in cars, and it is unloaded by a swing derrick. When the pile is about seven feet high, we cut the pyramid down by shoveling to make it level and to mix the lump coal with the fine so as to reduce the air space; we do this for every four feet in height or three times before we reach the twelve-foot level. When we have enough area on the



PILE DRIVER FOR MAKING VENTILATING HOLES

top to work on, we pull up our homemade "pile driver," made similar to that shown in the sketch.

It is light enough for three men to handle and is made from two 2 x 9-in. planks and two 3 x 3-in. posts with 2 x 3-in. braces. One single block with half-inch cotton rope is used to handle the 1½-in. diameter iron bar which can be driven through the coal in less than a minute. When the bar reaches the bottom, it is shaken sideways so as to pack the loose coal around the bar. Before pulling the bar up, it is necessary to make a casing of 10-oz. roof paper around the bar, coming just level with the surface of the coal. This is to prevent loose coal from falling into the holes when the bar is removed. We punch a hole for each 2.5 or 3 sq.ft. area. Three men are able to make about twenty-five to thirty holes in one hour. We store 5,000 to 7,000 tons of coal every year.

The pile is easy to check for temperature by lowering a thermometer in each hole. JOSEPH ESISZTER.

Berthierville, Canada.

Judging from my personal experiences with stored coal, I would say that in most cases it has been found that the coarser the coal is put on the bottom of a pile and covered with finer sizes, the worse it seems to heat.

Extinguishing a fire in a coal pile has always been successful when the water was applied to the bottom of the pile. This is accomplished by applying a nozzle to the top of the pile and pushing it down as far as the force of water will permit it to go.

Where coal is not piled over ten feet high, the bottom of the pile can be reached with the ordinary nozzle. If the pile is higher an extension pipe must be attached. From fifty to seventy pounds pressure is sufficient to penetrate the general run of nut and screenings, and a ⅝- to ¾-in. diameter nozzle is large enough where the fire has not spread too much. I cannot say how this will work on lump and run-of-mine coals, as the lumps might prevent working the nozzle down. Screening and nut are the only kinds I have dealt with.

By moving about on a pile at spaces of from three to six feet apart, it is possible to cover any fire under the pile. Sometimes a pile will need several applications of water before all trace of the fire is gone.

Pouring water on the top of a pile of hot coal is like pouring water on a duck's back, as it will go down but a small distance. It means either work through the top or in on the sides of the pile. It is surprising how much water a pile of screenings will absorb when applied as described. The fires always seem to start at the bottom of the pile.

The ventilating pipes, as shown in Fig. 7 on page 619 of the Oct. 19 issue, would be a good method of applying water in advance of any fire, thus cooling the pile and not giving the coal a chance to start heating.

Capping the pipes would stop ventilation if it were considered detrimental.

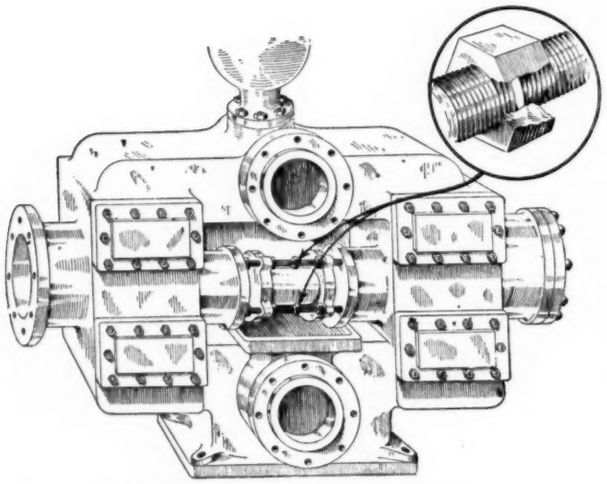
I have known screenings to be stored for two years and longer without taking fire; then again, other coals would not be in storage two months without a fire starting. Contrary to the common belief, the old coal showed, by actual analysis, very little depreciation from long storage. The foregoing applies only to coal fires in the incipient stage. E. G. HOPPE.

Cairo, Ill.

A Quick Pump Repair

A single-acting, center-packed boiler-feed pump that supplies water for two 150-hp. return-tubular boilers recently gave the operating engineer a chance to do some quick thinking. This pump is the only means for feeding the boilers, except when the pressure is lowered to 40 lb., when the city supply can be turned on. The plant operates six days a week, and twenty-four hours a day.

The engineer had instructed the fireman to pack the water end on Sunday. When he packed the pump, he



EMERGENCY STUFFING-BOX REPAIR

filled the stuffing boxes so full that he could not enter the glands by shoving them in by hand, so he put the nuts on and pulled the glands up with a wrench; the packing used was made of a composition of rubber and duck.

The pump was started on Monday morning as usual and ran until about 9 o'clock, when the four ¾-in. gland studs on the end toward the steam cylinder pulled out of the casting, because of the pressure and the packing swelling.

The engineer procured eight ¾ x 4-in. studs and sixteen hexagon nuts, and after screwing out the four studs on the opposite end, he put the studs and nuts in place in the form of a jackscrew, as shown in the sketch. It took one hour and five minutes to make this repair, repack the pump and have it forcing water into the boilers. C. J. MILLER.

North Tonawanda, N. Y.

Boiler Drum Pitted

In answer to Mr. Carter's letter, page 675 of the Oct. 26 issue, relative to pitting of boiler drums, I am of the opinion that it is caused by the carbonic acid and air that are present in the feed waters—in some more than in others. It is known that when water is heated it releases most of the air it contains and the temperature of dissociation begins at about 140 deg. F. If the circulation is poor, the air and carbonic acid adhere to the rough surface of the drum.

Strohmeyer says that feeding one ton of water per hour is capable of a wasting of six pounds of iron in twenty-four hours, assuming that all the water would come in contact with the iron. The drum of which Mr. Carter speaks may just be at the right dissociation temperature. I believe that every closed heater should have an air valve in the feed pipe just outside the heater. JOHN D. DESMOND.

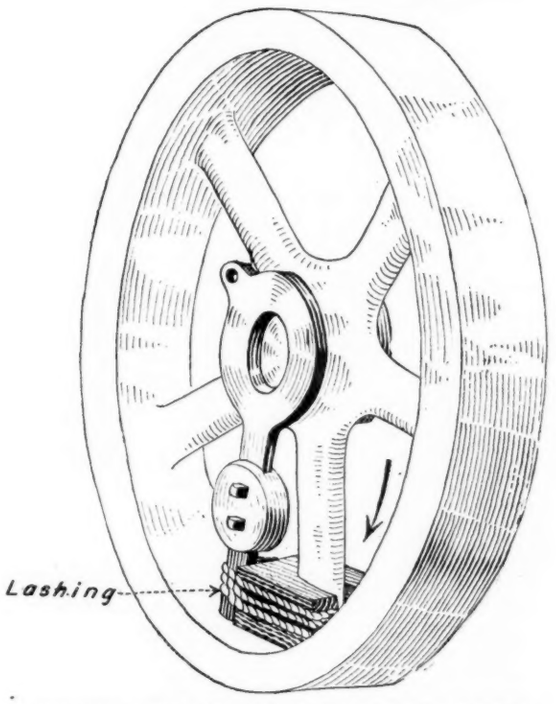
Milwaukee, Wis.

Carrying the Load with the Governor Disabled

We were running along one night, in a power house where I was chief engineer, with a 700-kw. load on a 500-kw. vertical turbine and an 800-kw. load on a revolving-field alternator directly connected to a 1,500-hp. vertical cross-compound engine with a 500-kw. direct-current generator on the other end of the shaft. This direct-current machine had no load.

The two alternators were in parallel when the governor spring on the engine broke and caused the engine to drop its load. This happened about 6:30 p.m., just before Christmas, when our peak load was on. This engine was controlled by a shaft governor which operated the admission valves on the high-pressure side; all the other valves were operated by eccentrics. As we did not have time to fit up another spring, I had the men lash the governor weight back against the stop as illustrated.

We started, with one man at the throttle, one at the condenser and one at the switchboard. The man at the throttle was given orders to obey signals from myself



WEIGHT ARM LOCKED TO FLYWHEEL SPOKE

as to opening and closing the throttle. The machine was brought up to speed, synchronized and put on the bus. We put the engine in on the condenser and opened up the throttle until the engine had its part of the load, the turbine doing the governing for both units. As the load fell, we closed the throttle of the engine so as to make the turbine do the governing. This goes to show that a governor is required on but one of the prime movers when the machines are operated in parallel.

East St. Louis, Ill. E. LITTLEFIELD.

Methods of Calculating Flue-Gas Losses

I recently chanced to leaf through an issue of *Power* (April 27, 1920) and found an article by F. D. Harger, entitled "Calculations from a Flue-Gas Analysis of Loss Due to Incomplete Combustion." Now this is not intended to take issue with Mr. Harger, but let it be said in passing that rarely, in my experience, has any CH_4 been found in the analysis of flue gas taken from the breeching of furnaces where the gases have had a chance to travel any of the usual distances through a boiler setting before they leave the heat-absorbing surfaces and pass to the stack. In fact, CH_4 is rarely found even in the first pass of any boiler where anything like ordinary combustion conditions are maintained. Then too, using an accurately calibrated 100-c.c. water Orsat equipped with a good bubbling pipette containing well-prepared ammoniacal cuprous chloride, all the CO that is ordinarily found in flue gas can be absorbed in three to four passes. The whole operation requires only about a minute and a half. A sample of pure CO can be absorbed in less than three minutes by this method. However, if an ordinary absorption pipette with vertical glass tubes is used, the rate of absorption will be much slower owing to the low viscosity of the CU_2CL_2 solution. If something could be found to thicken this solution, it might be used successfully in an ordinary pipette. Continuous analysis for CO is hardly worth while since conditions causing an appreciable amount of CO ought to be detected by the eye and remedied at once. Bulletin No. 135, United States Bureau of Mines, "Combustion of Coal and Design of Furnaces," shows a series of tables compiled over a long series of tests.

These tables trace the progress of combustion throughout a furnace, showing that CH_4 is confined to an area just above the fuel bed. Most of it is found at the surface or not more than 11 in. above. Beyond this point the CH_4 is almost entirely burned, and it is only a little farther on that the CO content materially decreases until by the time the uptake is reached there is only a few tenths of one per cent, if any.

But to return to Mr. Harger's reference to H. B. Brayton: An article by this author in *Power* (Feb. 17, 1920), "Calculations from a Flue-Gas Analysis," though substantially correct in most details, is by far more complicated than need be for the average boiler-room operator. An assumed analysis of coal given was: Carbon, 82.73; hydrogen, 4.63; oxygen, 4.42; nitrogen, 1.31; total, 93.09 per cent. Calculated calorific value, 14,480 B.t.u. The difference between this total and 100 per cent is presumed to be ash, sulphur and moisture, if the analysis were made on a "wet" basis. Fifty per cent excess air was assumed and average flue-gas temperature was given at 550 deg. F. outside air, 50 deg.

Now, instead of calculating heat losses from atomic weights and using a different value of specific heat for each gas, it is much simpler to start with a known flue-gas analysis. Since 50 per cent excess air was assumed, let us find an analysis that will give us that figure. With 12 per cent CO_2 and 6 per cent oxygen we have just 50 per cent excess air. This may be checked by using the formula for air required and air supplied:

$$11.5\ C + 34.5\left(H - \frac{O}{8}\right) = \textit{lb. of air required per pound of carbon.}$$

Submitting in the formula the values of carbon, hydrogen and oxygen found in the ultimate analysis of the coal, we find that 11.33 lb. of air is required. The formula for the amount of air supplied with 12 per cent CO_2 and 6 per cent oxygen is

$$3.036\left(\frac{N}{CO_2 + CO}\right) \times C =$$

$$3.036\left(\frac{82}{12}\right) \times 0.8273 = -17.16\ \textit{lb. of air supplied.}$$

$$11.33 \div 17.16 = 66\ \textit{per cent excess air.}$$

With the flue-gas analysis given, the dry-gas loss may be easily computed from this formula:

$$\textit{Loss} = W \times 0.24\ (T - t)$$

where

$W = \left(\frac{4\,CO_2 + O_2 + 700}{3\,(CO_2 + CO)}\right) C$ (C = per cent carbon in fuel);

0.24 = Mean specific heat of flue gases;
T = Stack temperature;
t = Temperature of outside air;

$$W = \frac{48 + 6 + 700}{36} \times 0.8273 = 17.32$$ lb. of gas per lb. of carbon.

$$\textit{Loss} = 17.32 \times 0.24 \times 500 = 2078.4\ \textit{B.t.u.}$$

$$2078.4 \div 14{,}480 = 14.3\ \textit{per cent loss.}$$

In computing the hydrogen loss the following formula is used:

$$9H\ [(212 - t) + 970.4 + 0.47\ (T - 212)]$$

where

H = Per cent of hydrogen in fuel;
T = Stack temperature;
t = Temperature of outside air;
970.4 = Heat of vaporization of water;
0.47 = Specific heat of superheated steam at atmospheric pressure and at temperature of escaping gases.

If any moisture value for the coal had been given, this value, expressed in per cent, could be added to the value of $9H$ and computation made. Substituting values in the formula, we have:

$$\textit{Loss} = 0.4167\ (212 - 50) + 970.4 + (0.47 \times 338)$$

$$H \text{ loss} = 538.07\ \textit{B.t.u.}$$

$$538.07 \div 14{,}480 = 3.7\ \textit{per cent loss.}$$

Since no particular kind of furnace is specified, 10 per cent is probably high for an average radiation loss and a nearer figure would be 6 per cent or under.

$$868 \div 14{,}480 = 6\ \textit{per cent radiation loss.}$$

Totaling the various losses, we find an efficiency of 76 per cent.

HEAT BALANCE

	B.t.u.	Per Cent
Dry-gas loss	2,078.40	14.3
Hydrogen loss	538.07	3.7
Radiation loss	868.00	6.0
Heat utilized	10,995.53	76.0
	14,480.00	100.00

Mr. Brayton obtained an efficiency of 75 per cent, but he did not obtain a high enough value for the hydrogen loss, as he only accounted for the heat lost in superheating the steam formed. This amounts to less than 100 B.t.u., whereas there are over 400 B.t.u. lost in raising the temperature of the water formed from the temperature of outside air to the boiling point and then evaporating it. The factors, 0.47 for the specific heat of superheated steam and 0.24 for the mean specific

heat of flue gases, are those used universally in computing heat losses.

Mr. Brayton did not account for any moisture in the coal nor any combustible in the ash, two factors that are sure to be present and together will cause a further loss of at least 3 or 4 per cent.

The simple formulas for computing dry-gas loss and hydrogen and moisture loss are the same as given in all standard textbooks on combustion. Bulletin No. 97, United States Bureau of Mines, "Sampling and Analyzing Flue Gases," has all the merits of any treatise on the subject and may be had for the asking. For plain, concise statement of facts, no better article has ever been written and every engineer, whether technically trained or not, will do well to read this bulletin.

East Chicago, Ind. J. R. DARNELL.

Ash Removal from City Plant

The editorial, "Ash Removal from City Plants," page 590 of the Oct. 12 issue, calls to attention a condition that is becoming serious in the large plants of the great cities. While ashes are now regarded as something of a nuisance, they may in time become, as have other waste materials, a valuable byproduct.

Analysis of coal ashes show them to be composed principally of the oxides of sulphur, silicon, iron, aluminum and calcium. Nearly all these compounds are necessary to the manufacture of portland cement and are found in varying proportions in both limestone and shale from which the cement is usually made.

In some cement plants the ashes from the boiler room are used in the raw-material mix. While this amount of ashes is small compared with the total mix, it is possible to use a great deal more without serious complications. In fact, it may be possible to replace the shale or clay entirely with ashes. This would, of course, give a mix of much higher iron and sulphur and a lower alumina content than is the usual practice. The immediate result would be a clinker that is easily burned, but because of the large iron content, is very hard to grind to the requisite fineness. It would also be very dark in color and heavier than normal cement. High-iron cement withstands the action of sea water better than the standard cement.

A thousand-barrel cement plant (which is a small one as cement plants go) will, if ashes supply the entire "argillaceous-material" requirement, take the ashes from a boiler plant of about 11,000 horsepower.

The economic considerations are the relative costs of quarrying the shale and of hauling the ashes coupled with the added expense of using them. In this connection the value of the 20 to 40 per cent combustible in the ashes should not be overlooked. This fuel becomes available in the rotary kiln which, of course, is the only type considered.

The ratio of dead to live load in concrete structures is very high as compared with structures of steel or wood, therefore, could a material be found that possessed the strength and enduring qualities of sand and stone and which was of much less weight, it should make a particular appeal to builders. Recently, concrete ships and freight cars have been introduced, and weight has been found a factor of considerable importance.

While the quality of light weight of cinders has been well known for many years, its use where the advantage of light weight is most desirable (in reinforced-concrete buildings) has been very limited because of the danger of corrosion of the reinforcing steel; and to free cinders of the unburned coal to the extent of making them safe for use in reinforced concrete would probably cost more than anyone would care to pay for the advantage gained.

By subjecting ashes to a high temperature in a rotary kiln, the combustible will be burned out and the noncombustible may be vitrified. The resulting clinker may then be crushed and screened and will become a very good, light-weight aggregate, suitable for concrete. This material will have all the good qualities of the untreated ashes and will be free from the liability of corrosive action on the reinforcing steel. A concrete aggregate that has the strength of sand and stone and about half their weight should, if the prices compare favorably, find a ready market.

In discussing the economics of this ash-treating plant, it should be credited with the cost of ash removal as formerly practiced. Also, it will be found that the fuel content of the ashes is nearly sufficient to produce the desired effect, so that the fuel charge will be comparatively small. C. O. SANDSTROM.

Kansas City, Mo.

Don't Blame the Fireman

The poor firemen get little consideration from the hands of contributing engineers, who in most cases find them ignorant and prone to do the necessary work of the plant in the easiest way possible, regardless of the waste of fuel.

It has been said that the greatest gain in economy in power-plant operation will, in the future, be made in the boiler room, but no owner has a right to expect very much in the way of material gain if he does not do his part. It is unfair to expect the fireman to make much improvement in boiler operation if the owner does not provide the instruments necessary to guide him in his work.

High boiler efficiency will be secured only when the fuel is properly fired, the heating surfaces kept free from scale, soot and ash deposit, the boiler setting free from air leaks and the gas passages unobstructed. All but the matter of gas-passage obstruction are under the control of the fireman. There is something more that governs the efficient operation of the boiler plant; that is, the fuel must be burned within the furnace, and to do this properly the right volume of air must be supplied to the burning fuel. If not, incomplete combustion results, producing a lower CO_2 and the temperature of the chimney gases is increased.

But how is a fireman to know how hot the flue gases are or whether excess air is being supplied to the furnace if the proper instruments are not provided for his guidance. If a plant is suitably equipped with the necessary instruments, the operation should be a continuous boiler test and then results can be expected.

The best fireman on earth cannot get the best boiler-room results unless he has means of knowing what he is doing. Firing boilers by rule of thumb will not get the best results, although that is the way many boilers are operated. This is not because the fireman would not do better if he could, but because he is doing the only thing he can do with what he has to work with.

Do not condemn the fireman until he shows that he does not try for better results when proper instruments have been supplied for his guidance.

St. Louis, Mo. O. B. BASSETT.

INQUIRIES OF GENERAL INTEREST

Use of Loop or Siphon for Connecting Steam Gage—Why is a loop used in connecting a steam gage to a boiler? R. N.

A loop or siphon is placed in the connection between the boiler and the gage to trap water of condensation in the connecting pipe, so that steam will not enter the gage tube and affect its stiffness.

Necessity of Auxiliary Steam Valve on Single Pumps.—On a single-cylinder steam pump, why is it necessary to have an auxiliary steam valve? W. C.

If the main valve of the pump were mechanically connected to the piston rod of the pump, the steam port would be covered slowly toward the end of a stroke, the stroke would not be completed and the valve would not reverse. Therefore an auxiliary valve is necessary to operate the main valve.

Increasing Length of Bearing May Reduce Friction—Does increasing the length of a bearing add to the power required to overcome friction? W. A.

For the same materials and finish and same lubrication, up to the point of cutting or abrasion of one surface or the other, the loss of power by friction is directly as the total pressure and independent of the area of the rubbing surfaces. Therefore increasing the length of a bearing does not add to the power required to overcome friction, but on the other hand may reduce the resistance by prevention of cutting or permitting of better lubrication from reduction of the pressure per unit of area of the rubbing surfaces.

Changing from Natural Gas to Producer Gas—The natural gas for our gas engine will shortly be shut off. Is it possible to use producer gas without any great change to the engine? What will be the fuel consumption? G. E.

Producer gas may be used, and all that is necessary is to install a producer. The engine will require no alteration beyond a possible change in the compression and in the proportions of gas and air passing through the throttle valve. Any of the well-known producers will deliver enough gas from anthracite coal to allow the engine to develop a brake horsepower on 1¼ lb. of anthracite pea or buckwheat coal.

Increasing Power Developed by Engine—In how many ways can the horsepower of a non-condensing engine be increased? C. W. M.

Assuming that all bearings and working parts are adapted to the changed conditions, the indicated power of an engine is increased for a given m.e.p. by increasing its speed, or by increasing the m.e.p., and the actual or brake horsepower developed for a given indicated power can be increased by reducing the friction of the engine. The m.e.p. can be increased principally by supplying steam of higher initial pressure, by obtaining later and sharper cutoff, by obtaining release later in the stroke, by increasing the percentage of clearance (provided the steam does not follow full stroke), reducing the losses due to cylinder condensation by using a non-conducting lagging or steam jacketing, or by heating the cylinder without raising the temperature of the exhaust; reducing the back pressure by a freer exhaust or by condensing; and by improving the tightness of the piston, the steam and the exhaust valves. But under some conditions the increase of friction for reduction of leakage may be so great that the actual power will not be increased as much as the indicated.

Inside Lap for "Cushioning on the Exhaust."—What is meant by inside lap of an engine valve and what is its effect in the operation of an engine? R. G. L.

The lap of a valve is the distance its edge overlaps the port when the valve is in the middle of its travel. The term inside lap, when applied to a D slide valve, refers to the distance the exhaust edge of the valve overlaps the exhaust port when the valve is in the central position. Inside or exhaust lap therefore results in closure of the exhaust port before the piston reaches the end of its stroke. The exhaust steam then remaining in the cylinder is thereby compressed and acts like a cushion for gradually arresting the piston as it approaches the end of the stroke, and hence the operation is commonly referred to as "cushioning on the exhaust."

Purpose of Dash-Relief Valves on Pump—Why are dash-relief valves placed on the steam end of a pump, and do they make any difference in the regulation of the stroke of a pump? W. H. C.

Dash-relief valves are used to control the amount of opening of a communication between the exhaust passage and the regular live-steam passage, which is near the end of the cylinder and which remains covered by the main steam valve until it reverses. The communication between the passages with its adjustable valve is simply a controlled leak to regulate the amount of cushioning and useful in slightly lengthening the stroke in case of excessive cushioning after the piston has covered the exhaust passage, especially when the pump is working slowly and with a heavy load.

Size of Safety Valve for Compressed-Air System—What is the largest safety valve permissible on an air compressor? L. W. R.

For safety there would be no limitation of the maximum size. There is, however, a limitation of minimum capacity. The Massachusetts Air-Tank Regulations, which were carefully prepared, specify (a) that the maximum commercial rating sea-level pressure and 60 deg. F. of any air compressor shall be the piston displacement in cubic feet per minute at the maximum speed as given in the catalog of the manufacturers, and (b) the safety valve connected to an air-compressor system shall have, when adjusted to give the maximum discharge area for satisfactory operation, a capacity capable of discharging a quantity of air at least equal to 25 per cent excess of the maximum rating of the air compressors operating on said system, without the air pressure rising over 5 per cent of the allowable pressure.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Service Experience with Condensers*

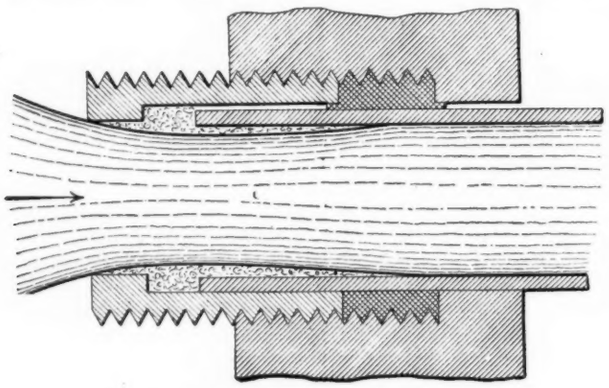
By Engineer Lieutenant-Commander G. B. Allen, R.N.

IN THE early days of low powers and comparatively high ratio of machinery weight in war vessels, a high standard of purity of feed water was not absolutely essential, and owing to its protective qualities a certain amount of boiler scale was not particularly objectionable. Under these circumstances the boilers were frequently worked with a slight density, and the admission of small amounts of salt water to the feed was a matter of no great moment, and indeed would not ordinarily be detected.

The demands for maximum power on a minimum weight necessitated the development of the water-tube boiler, which in its present form is peculiarly sensitive to the quality of feed supplied, and a condenser defect which formerly would have been regarded as of little importance is now attended by results out of all proportion to the magnitude of the defect itself.

Among the immediate results following upon such a defect as a small perforation are:

1. A rise in the density of the boiler water followed by priming (that is, the passage of water with the steam through the system), with consequent possible damage to fast-running reciprocating auxiliaries and undue wear (erosion) of turbine nozzles in modern vessels; and unless the evaporation is considerably eased and the engines either



FLOW OF WATER INTO CONDENSER TUBE

slowed down or stopped, the mechanical damage caused by the water passed over may be considerable.

2. The deposition of scale upon the heating surfaces.

3. The beginning of serious corrosive action in the system, including both boilers and turbines, the first named being particularly severe in the highly forced boilers of the present day.

It is on these grounds, both of reliability and durability, that the importance of maintaining a pure "feed" rests.

Fortunately, the proportion of defective tubes compared with the number of tubes on service is extremely low and is not greater than 50 in 1,000,000 per annum; but if it be realized that in a large vessel fitted with some 48,000 tubes of a total length approximating to 115 miles, such a small defect as a $\frac{1}{16}$ in. diameter pin hole or one cracked tube may render the vessel unmanageable in a moment of great stress, it will be evident that it is a matter of great importance to secure immunity from such defects, and, moreover, one that requires considerable investigation and joint cooperation between the manufacturer, the metallurgist and the user.

Many of the early difficulties experienced were found to be due to faulty design and manufacture, but these, which concerned accuracy of fitting rather than faults in the tubes themselves, have been gradually eliminated. Defects of this nature may be summarized as follows: insufficient support of tubes between the tube plates; holes in diaphragm plates too large; holes in tube plates too large or too small; unsuitable packing; slackness of ferrules in tube plates; steam or drain orifices unsuitably placed, allowing steam and hot water, sometimes contaminated with oils, to impinge on certain tubes.

*Abstract of a paper before the Institute of Metals, Barrow-in-Furness, England.

Insufficient Support of Tubes

Insufficient support led to undue vibration of the tubes, and although this has been largely rectified by the provision of suitable and unequally spaced diaphragm plates and by limiting the diameters of the tubes and the holes through which they pass, a certain clearance must of necessity be allowed; and the effect of vibration, more especially in high-speed vessels, cannot be ignored.

Experience has shown the necessity of adhering to rigidly defined limits in regard to the tolerances of tubes and holes in tube plates, both on the score of guarding against the fit being too close, with consequent abnormal strain thrown on the tubes when screwing up the glands, and also of guarding against too loose a fit, resulting in the packing being forced between tube and tube plate and probable leakage. Similarly, the exact concentricity of ferrules and tubes within narrow limits is of importance. Since the adoption of limiting clearances, defects of this character have to all intents and purposes been eliminated.

Opinions concerning the suitability of packing materials vary, and outside the service there appears to be little uniformity of practice. Experience in naval vessels shows that the linen gromet made to present Admiralty specification gives every satisfaction, and with ferrules and their stuffing boxes screwed to correct gage, difficulties due to gland leakage may be regarded as having been coped with successfully.

Investigations into the general problem of the nature of the underlying causes of corrosion within the alloy itself have resulted in various theories, none of which has as yet met with general acceptance, and in the present stage the most we are able to do is to endeavor to trace each defect to its immediate observable source.

The information available at the Admiralty is derived from reports forwarded by ships as failures occur. The following statement has been deduced to show the present causes of failure in the proportion in which they have occurred:

	Per Cent of Total Failure
(*a*) Deterioration at inlet ends	18
(*b*) Perforation due to local pitting	14.8
(*c*) Perforation due to obstruction	14.8
(*d*) Perforation due to steam impingement	5.4
(*e*) Crushed ends	5.4
(*f*) Splitting	10.8
(*g*) Perforation due to contaminated circulating water	1.0
(*h*) General corrosion	29.8

The large proportion of failures due to deterioration at the inlet ends of the tubes is noteworthy. Generally speaking, there is a marked thinning away at the ends of the tubes (not infrequently accompanied by wear of ferrules) culminating in perforation at from one to three inches from the end.

Air a Contributory Factor to Deterioration

In many cases where the greatest intensity of the deterioration occurs at the upper inside surface of the tube, the presence of air has been held to be the chief contributory factor, and under such circumstances the provision of air-releasing devices at the highest point of the circulating-water system has proved of marked benefit. However, with all such mechanical precautions the evacuation (before entry to the tubes) of air which is necessarily in suspension in the circulating water is at the best only partial. This is more especially the case in high-speed shallow draft vessels, and as will be evident from an examination of the sketch, the sharp edges both of ferrule and tube, assisted

to some extent by the possibility that the tube and ferrule may not always lie perfectly concentrically, tend to break the flow of water and to form pockets of an unstable nature where air may be reasonably expected to accumulate.

This type of defect has been particularly noticeable in vessels serving in shallow waters containing a considerable proportion of solid matter, for example, sand, chalk, etc., and this, together with the comparatively high water velocity through the tubes, points to the influence of erosion or the abrasive action of gritty particles as being of considerable importance. The presence of such gritty matter cannot, of course, be avoided on service, and it appears that investigations with regard to the elimination of this type of defect must take the lines of endeavoring to obtain a metal whose surface is better able to withstand this abrasive action.

Perforations Due to Local Defects

Whereas in the cases of tube-end deterioration the number of tubes affected in any condenser (apart from those which actually fail) may be considerable; cases of local pitting are rarely evident in more than one or two tubes in the condenser concerned, and when once a failure has occurred and the tube plugged or replaced, little further trouble is experienced. In these cases perforation occurs at isolated spots, and the failure has been generally considered to be due to some local defect, for example, a spill or lamination. To quote the author of a previous paper on this subject, "The importance of spills cannot be exaggerated,"[1] and the elimination of defects of this character is entirely a question of the manufacture of the mechanically perfect tube, which desirable result can be attained only by the drawing down of a mechanically perfect cast shell. The practice of turning and boring each shell, even if regarded as merely for purposes of exploration of the metal immediately beneath the surface skins, has a considerable safeguarding effect toward the reduction in the number of such surface irregularities, as may be discovered on sighting.

Perforations, the cause of which has been directly traced to obstructions, were particularly prevalent in coal-burning ships where the ashes were discharged beneath the waterline, and though it is possible to nullify the effect of a vessel's own refuse by suitably placing the ash shoots and by the adoption of oil-fuel firing, yet such obstruction of tubes by cinders, etc., may still be caused by refuse from other vessels.

The recorded cases where failure has occurred through the impingement of steam and water directly on a limited area of the outer surface of certain tubes are few, and in general have been confined to condensers other than those of Admiralty design. Such failures should not occur, provided orifices are suitably placed and baffled.

Failures Due to Crushing

The proportionate number of failures due to crushing is small, and these may be regarded as isolated cases. In no case has it been established that over-tightening of screwed glands has been resorted to, and the fact that crushing sometimes does occur, serves to emphasize the importance of the tubes being sufficiently hard to stand a reasonable margin of pressure due to tightening up above that absolutely necessary to secure watertightness, though it may be remarked that crushing is sometimes observed as a natural result of the weakening of tubes which have been attacked internally by corrosion of a general nature.

There is some divergence of opinion as concerning the most desirable degree of purity of the 70 : 29 : 1 alloy, but investigation has shown that a large proportion of the tubes which have failed from splitting have been manufactured from materials of a lower standard of purity than that required by the Admiralty specification.

Apart from the question of purity of constituents, the internal condition of stress in the finished tube must have considerable bearing on the liability to season cracking and splitting. The work done during the final draw (which must be such as to leave the tubes sufficiently hard to stand the test of grometing) of necessity leaves the material of the tube in an indeterminate condition of internal stress, and anything that can be done which will eliminate this internal stress, while at the same time allowing the tube to retain the requisite hardness, will be of great benefit in minimizing defects from this source.

The case in which failure has been directly ascribed to the use of unsatisfactory circulating water is exceptional, but it certainly gives weight to a widely held opinion that the conditions under which many condensers are worked in the early stages of their life (for example, in comparatively stagnant fitting-out basins contaminated by various kinds of refuse) are conceivably of importance as a primary cause of tube decay. On the occasion referred to the vessel had been anchored in waters contaminated by sewage, and the case is quoted as emphasizing that materials for marine usage should be able to resist corrosion under varying conditions which do not allow of the selection of particular materials to suit particular waters. The deleterious effect of vegetable oils has already been described before this Institute,[2] but the writer is not aware of any experiments having been carried out to determine the effect of oil fuel in regard to the acceleration of corrosion; though it may be remarked that in one of H.M. vessels which reported a considerable number of defective tubes within two months of entering into service, no definite cause could be traced beyond that extended basin trials had been carried out in comparatively stagnant water contaminated by a considerable leak from one of the ship's tanks.

Failures Caused by General Corrosion

The proportionate number of recorded failures due to general corrosion does not adequately express the importance of this class, these being cases of actual failure only, that is, general corrosion culminating in perforation; whereas the great majority of cases in which general corrosion is present are not recorded, and it is the possibility of failure at an unknown moment which gives this matter so serious an aspect.

Leakage from electric circuits has been put forward as being a contributory cause of corrosion, but though no evidence of a positive character has been obtained in support of this contention, it has been observed that failures have occurred shortly after the discovery of "grounds" and it is probable that the effect, if any, is one of acceleration rather than a primary cause.

The general problem of corrosion of condenser tubes may be conveniently regarded from four different standpoints:

1. The arrest or prevention of corrosion in condensers as at present constructed.
2. The treatment of tubes of accepted composition.
3. The general design of condensers.
4. The utilization of more suitable alloys than those at present in use.

The provision of steel protector plates and cast-iron water-ends has proved satisfactory in checking the rate of deterioration provided that good conditions are secured, but at the same time considerable wear of the cast-iron ends takes place, and this wear if excessive is an undesirable feature. The present Admiralty practice is to make the tubes and tube plates of as nearly the same composition as is practicable and to secure steel slabs direct to the tube plates, but from the foregoing remarks it cannot be said that this practice is entirely effective.

The Cumberland Process

The Cumberland process has been fitted in certain vessels, but beyond the fact that it has been found that this process has not arrested decay where such decay has been in evidence before the process has been installed, the experience gained has not been sufficient to allow of any reliable conclusions being drawn.

With regard to the treatment of working tubes, the Admiralty (acting on a well-known and successful practice of coating corroded copper pipes with a film of pitch and marine glue) have experimented with resistant varnishes. In the first vessel treated, although a certain degree of protection was obtained, it was found that, probably as a

[1] Bruhl, *Journal of the Institute of Metals*, 1911, Vol. VI, p. 304.

[2] Bruhl, *Journal of the Institute of Metals*, 1911, Vol. VI, p. 291.

result of the erosive action of the water (but possibly on account of the difficulty of forming a film of even thickness and of satisfactory drying), the varnish became washed away in places, thus exposing portions of the bare metallic surface to the action of the water. Experience with a second vessel has not been extensive, but it is understood that general corrosion which formerly resulted in comparatively frequent failures has been entirely arrested. In these cases the varnish has been applied to the tubes "in place" and dried by the admission of steam to the condenser, and it is probable that such a process carried out on tubes before being fitted would be of considerable value, provided that the surfaces formed withstand the work of fitting in place and prove sufficiently resistant to abrasive influences.

The protective value of an oxide film has been suggested by a former report of the Corrosion Committee, and the Admiralty have under observation a vessel fitted with tubes on which such a film has been formed. Unfortunately, this vessel has done little steaming and no useful data have as yet been obtained.

In regard to the elimination of failures caused by surface defects, for example, spills, a vessel has been fitted with compound tubes made on the lines suggested by Sir Charles Parsons,[3] but here again owing to post-war conditions it has not been possible to obtain any conclusive results.

The Admiralty have from time to time experimented with tubes of various compositions, but experience to date has shown that the tubes made to Admiralty specification have proved the most satisfactory under the varying conditions imposed by naval service.

Germany May Take Over Coal Mines

What to do with the coal mines is one of the biggest questions in Germany today, and there is a popular clamor for nationalization of the entire coal industry, fostered principally by the radical classes. Responsible politicians and business men, however, are in many cases taking the same stand, not only because of the necessity of making some concession to the socialistic doctrines of the working classes, but also on account of the glaring faults of the present system, under which the country's coal resources are largely in the hands of a few men. These men have achieved tremendous wealth and influence; in fact, some of their coal companies in the last business year made net profits which exceeded their whole capital.

Some time ago, the government was forced to organize a committee to study the subject and make recommendations. This committee has not yet presented any feasible solution and is now being urged to take decisive action. It is composed of members of the National Economic Council and the National Coal Council, and of representatives of employers and employees.

The supporters of the nationalization of coal mines may be divided into two groups, according to the methods which they propose. One is headed by Professor Lederer, National Economist of the University of Heidelberg, and Rathenau, general manager of the A. E. G. concern, while the other group is represented by Stinnes, the German coal king. Professor Lederer and Rathenau agree that the total coal production shall at once be taken over by the government. Professor Lederer, whose proposal is the official one, believes that the mines themselves should be taken over by the state, and the owners divested of all proprietorship against payment of bonds corresponding to the value of the mines, whereas Rathenau proposes to leave the mines in the hands of the present owners for thirty years. In this case, however, the mine owners would be compelled to give up the total production of their mines at cost price plus an adequate profit, providing for a premium on increased production as a stimulus in this direction. In other words, one wants operation by the government itself, and the other wants operation by the owners simply as agents of the government.

The second group is totally opposed to either of these ideas. It is headed by Stinnes, probably the wealthiest and most astute business man of present-day Germany. His opinion is that the government would be utterly unable successfully to operate the mines, and that under government operation individual ambition, initiative and reward would be entirely lacking. His idea is that of co-operation, as opposed to nationalization. His plan is to make co-operative combines of large coal consumers like gas works, electricity works, water works, and a corresponding number of coal mines sufficient for their supply. The largest works, however, would merge with coal mines independent of other works. Each group would have a board which would regulate prices and distribution, and in this the consumers would have the majority. He believes also that the consumers should gradually assume control of the coal mines by buying up their stock against their own stock.

It is expected that these combines would consist not only of coal mines, but also of iron- and steel-works, with a corresponding number of manufacturers of finished articles; the idea being that the great amount of energy now wasted by all manufacturers in procuring fuel and raw material can be saved by linking together the chain of production from the producer to the manufacturer. This proposition is being strongly advocated among prominent industrial leaders; in fact, quite a number of them are acting upon it without awaiting the conclusion of the nationalization problem. Several of these combinations, or trusts, have been formed lately; the largest of them was the work of Stinnes himself.

Public opinion seems to be inclined towards Rathenau's proposal for state-controlled private operation rather than Stinnes's ideas of amalgamation. It is feared in many quarters that although his plan is to put the consumers in control of each trust, the coal producers, being in the strongest position, would assume control of the finishing stages and therefore of the entire combination. It is impossible to foresee at present which party will ultimately win; it seems likely that the final result will be a compromise.

Employment Conference Held in Chicago

A conference on employment and education, which was sponsored by the American Association of Engineers, was held in Chicago recently. This conference had for its purpose the stimulation of thought and discussion on the problem of educating the man and placing him in the right job. It was attended by educators, employment managers, engineers, experts on vocational and industrial education, character analysis, and others interested in education and employment.

Two resolutions were passed, one of which is exceedingly interesting in that it indicates that employment methods are already recognized as desirable in higher education. This resolution read: "Resolved, That personnel work is necessary in engineering schools, and should be provided wherever possible." Probably no other thought was so well-defined among those present as that there must be better selection of the wheat from the chaff in engineering education.

The other resolution read: "Resolved, That it is the sense of the educational delegates that the best teachers in the schools, training engineers, should be placed in charge of the more elementary work." Both resolutions were introduced by Dean E. J. McCaustland of the University of Missouri.

The conference was not intended to concern itself entirely with engineering education, nor did it; but the presence of some engineers on the program gave an engineering flavor to the subject matter of the addresses.

The engineering educators and the practicing engineers had a battle royal over the efficacy of a college education. R. O. Kramer, manager of the mechanical department of Montgomery Ward & Co., advocated the establishment of courses in management in the technical schools with a view to providing engineers with the preparation for their truest and best field of service—executive positions in the industrial and business world. Dean A. A. Potter of Purdue University upheld the work of the engineering schools with the remark that the technical world demanded a specialized

[3] *Journal of the Institute of Metals*, 1911, Vol. VI, p. 305.

product to a certain extent, but that the aim of the schools was to give a broad fundamental training which would adapt the graduate-engineer to any field of work he might enter.

J. H. Libberton, of Chicago, manager of the service bureau of the Universal Portland Cement Co., urged that the student be started out right in college by first being interviewed by a vocational advisor. He disagreed with the statement regarding college activities made by E. Davenport in an article in *The Saturday Evening Post* for Nov. 13 and urged the participation of the student in such activities to develop his initiative and imagination. He also recommended the securing of the best possible talent for teachers, who should be encouraged to engage in the practice of their profession.

John B. Densmore, director-general of the United States Employment Service, advocated a national clearance system of employment, operated very closely with the educational systems of the country. He deplored the present-day education by age instead of according to native ability and the lack of scientific methods of measuring abilities in the schools and colleges. A national clearance system would reduce the present duplication of expense of engaging men and women incurred by employers and the expense of finding positions for graduates incurred by educational institutions.

Professor A. F. Payne, of the department of trade and industrial education in the University of Minnesota, in speaking on "Vocational Analysis and the Engineer," said that "very few of our engineering colleges have as yet realized that most of their students eventually become administrators and executives, and in the vast majority of cases are managers in more or less degree." Inasmuch as the engineer is usually the only man in industry who has been scientifically trained in a scientific manner, the responsibilities of vocational analysis fall upon him. Mr. Payne outlined the methods of vocational analysis and determination of mental capacities. He strongly advocated a scientific selection of workers into proper vocations as a means of increasing prosperity and happiness.

Chicago Section A. S. M. E. Celebrates Fortieth Anniversary of Society

The Chicago Section of the American Society of Mechanical Engineers celebrated the fortieth anniversary of the society on the evening of Nov. 22. Souvenirs consisting of photostat copies of autographs of all members attending the first annual meeting held in New York City in 1880 were distributed. A similar record of autographs of Chicago members present at the Fortieth Anniversary meeting was made to be forwarded to New York for historical record. Anniversary speeches by Fred J. Miller, president of the society, and Dr. I. N. Hollis, president of Worcester Polytechnic Institute, were reproduced on the phonograph. During a short business meeting telegrams of congratulation were read from a number of prominent men, including Harding, Coolidge, Hoover, Gompers and others.

In a few introductory remarks Prof. Herbert S. Philbrick, chairman of the section, called attention to the fact that the greatest development in mechanical engineering has taken place during the last forty years and has been almost coincident with the upbuilding of the A. S. M. E. To be convinced of the progress made and the importance of the work done by the society, he remarked that it was only necessary to read over the list of presidents, all noted men in the mechanical field. It was his view that the future is as attractive now as it was forty years ago, and it was his hope that the progress of the society in the next forty years would be as great as the advancement it has made so far.

Captain Robert W. Hunt gave early recollections of the society that was nearest to his heart. He was not one of the founders, but had joined the society in its first year in 1880. His associations with prominent members at that time were recalled, and mention was made of some of the early presidents. He felt that in the continued progress of the society the secretary was of first importance, and that in this connection credit must be given to Frederick Hutton, to whom, more than to any other man, the wonderful success of the organization had been due.

A short summary of the first meeting of the American Engineering Council of the Federated American Engineering Societies, held in Washington from Nov. 18 to 20, was given by Arthur L. Rice.

The speaker of the evening was Dr. G. O. Smith, director of the United States Geological Survey. Speaking on "Industry's Supply of Energy," he gave a great deal of interesting data on the various sources of energy, including coal, water power, oil and natural gas, the estimated quantities available of each, the length of time that they should last at the present increasing rate of consumption and the primary horsepower installed.

Refrigerating Engineers Holding Annual Meeting

The American Society of Refrigerating Engineers is holding its sixteenth annual convention this week at the Hotel Astor, New York City. Meetings will be held on Dec. 6, 7 and 8. The program follows:

Monday, Dec. 6—Morning session, 10 o'clock: Routine business. Afternoon session, 1:30 o'clock: Discussion of Revised Refrigeration Code. "Refrigeration in Russia, and America's Participation in Its Future Development," Prof. N. A. Borodin, Russian Committee on Refrigeration. "National Department of Public Works," J. Parke Channing, Chairman of Engineering Council. New Refrigeration Data. (Members and others having engineering data, which have not been previously published, are requested to present them.) Evening Session, 8 o'clock: Paper and progress reports by members of the staff of the National Bureau of Standards, Washington, D. C.; "Specific Heat and Specific Volume of Superheated Anhydrous Ammonia Vapor." "Table of Properties of Anhydrous Ammonia in the Saturation Region." "A Clearance Volume Meter," H. C. Dickinson, National Bureau of Standards. "Total Heat Diagrams," E. F. Mueller and C. H. Meyers, National Bureau of Standards. "Pressure Relief Diaphragms," H. F. Stimson, National Bureau of Standards.

Tuesday, Dec. 7.—Morning Session, 9.30 o'clock: "Transportation Economies of the Refrigerator Car," H. C. Newlean, Chicago, Ill. "Concrete Brine Tanks," Lieut. Col. H. C. Boyden, Chicago, Ill. "The Isometrics of the Superheat and the Vapor Pressure of Liquid Ammonia," F. G. Keyes, Cambridge, Mass. Afternoon session, 1.30 o'clock: "Thermit Welded Pipe Joints," R. L. Browne, Boston, Mass. "Oxyacetylene Welding of Refrigeration Apparatus," Fred E. Rogers, Jersey City, N. J. "Resistance Welding and Its Application to Refrigeration Machinery," J. H. Gravell, New York, N. Y. "Electric Arc Welding of Refrigeration Equipment," H. C. Unland, Schenectady, N. Y. Evening, 7 o'clock: The annual dinner, at Hotel Astor, Broadway and Forty-Fourth Street, New York; informal dress; ladies invited; subscription, $5 per cover. Addresses: United States Army, Col. Raymond Sheldon, Assistant Chief of Staff for Military Intelligence. Motion Pictures, Showing the Manufacture of Wrought Iron Pipe, Wyman Howell, New York City. Motion Pictures of Spanish Scenes.

Wednesday, Dec. 8.—Morning Session, 9.30 o'clock: "Control of Corrosion in Refrigerating Systems," F. N. Speller, Pittsburgh, Pa. "The Use of Refrigeration in Air Conditioning," Lee Nusbaum, Philadelphia, Pa. "Safety Devices for Household Refrigerating Machines," H. E. Willsie, Darien, Conn. Afternoon Session, 1.30 o'clock: "Modern Propellers for Brine Circulation," E. A. Burrows, Chicago, Ill. "Electric Current Rates for Refrigerating and Ice Making Plants," S. Bennis, New York, N. Y. "The Unaflow Steam Engine," Robert Cramer, Chicago, Ill.

The Board of Trade of Alberta, Canada, has appointed a committee to investigate the possibilities of the waste coal from the mines in the generation of electricity in a large central plant and of the proper distribution of this power to manufacturers and municipalities nearby. The fuel, which is very low in price, is being tested with a view to increasing its efficiency by pulverizing.—*Valve World.*

Some Opinions on the Petroleum Outlook from the American Petroleum Institute

The American Petroleum Institute has been very active lately in seeking light on problems of oil supply, both present and future. Excerpts from two speeches which were presented at its annual meeting held in Washington recently are presented herewith, together with an abstract of the memorandum prepared by the secretary of the institute for the Federal Trade Commission.

The Dyer resolution requires the Federal Trade Commission to make "inquiry and investigation into the causes of the recent advances in the price of fuel oil, kerosene, gasoline and other petroleum products." The American Petroleum Institute in its memorandum takes the stand that these increases are due simply to the great extent of consumption over production and not to any combination or any sort of collusion. Production in 1919 was greater than consumption by 2,160,000 bbl., but that condition did not hold true throughout the year. A radical change took place about Aug. 1st, 1919, for from that time on consumption has exceeded production at the rate of 33,717,240 bbl. annually. As it was just about this time that prices began to rise so noticeably, the inevitable inference is that the change in the relation between consumption and production was, and is, the cause of higher prices.

This condition is not due to any decrease in production, for there has been a considerable increase in the past year; it is, instead, the result of an enormously increased demand. The revival of industries, the increase of shipping and the shortage of coal have all had their part in bringing it about. But the greatest demand is, of course, for gasoline. From 1911 to Jan. 1, 1920, the number of automobiles increased 979 per cent, while the production of crude oil increased only 71 per cent.

Competition as it exists in the oil industry makes impossible any combination or trust. The very size of the industry precludes the possibility of a corner in the ownership of producing properties. There are more than 16,000 individuals and corporations engaged in the business of producing petroleum in the United States. The average oil field is a checkerboard of ownerships, and values have become so high that the capital necessary to buy or to control production is not available to any company or group of companies. The oil produced in the United States in 1911 was worth $134,044,752; it will be worth in 1920 about $1,260,000,000. Contrary to the popular idea, the Standard Oil Company of New Jersey and its former subsidiaries do not control the ownership of production in the United States; the production owned by these companies amounts to but 17 per cent. of the total volume in the country.

In spite of the alarm over the petroleum situation felt by many, this report is optimistic; it concludes:

> The oil business has ever met every public and private demand, and we are confident that it will continue to do so through: Conservation of petroleum and its products; increased production; increased importations; increased efficiency in the construction of automobile engines (a great change in this respect is probable); and increased efficiency in refining; that is, getting more gasoline and other valuable products out of each barrel of crude.
>
> To attain these ends, it will be necessary for the petroleum industry to have the co-operation of the public and the Government of the United States, both at home and in foreign lands.

Mr. Teagle Discusses Foreign Relations

W. C. Teagle, president of the Standard Oil Company of New Jersey and chairman of the committee on foreign relations of the American Petroleum Institute, in his address before the society, discussed "The World's Petroleum Problem." He felt this problem to be one of the few really big questions on which thinking men the world over are spending a good deal of energy.

Mr. Teagle stressed the point that the United States has been drawing upon its reserves to supply Europe's needs, and that now that our own demand has become so great, we should demand the opportunity of developing oil in foreign lands on an equal basis with other nations. He brought up the question of whether such development should be undertaken by the Government or by individuals, and pointing out the failure of the nationalization of oil lands in France, England and Russia, he declared emphatically that the oil business should be privately conducted and given a free rein, as has been successfully done in this country.

On the other hand, many foreign governments are deliberately placing obstacles in the way of those who would like to assist in the development of new sources of supply. This condition appears to exist in Mesopotamia, Turkey, Asia, Japan, Dutch East Indies and very markedly in Mexico.

If foreign governments insist on pursuing the policy of nationalizing oil lands and reserving subsoil rights to be held under government direction; if they persist in attempting to keep all their own petroleum products for their own future benefit, while relying upon the United States for a large share of their present-day needs, then, and in that event, this nation will have no alternative but to take cognizance of the attitude of foreign governments and, as a matter of necessary self-protection, to consider the adoption of measures reciprocally to conserve its petroleum resources for its own people.

With its position in world trade and the economic and financial weapons ready to hand, the United States could undoubtedly compel a new allotment of foreign oil territory so as to give it a share of what other nations are now proposing to keep for themselves. But we do not propose this. Might never makes right, and the smaller countries without similar means of forcing their way into such a division deserve better treatment at our hands.

Moreover, we do not believe any such measures will be necessary. The world is too anxious for petroleum. This it can obtain only if there be maintained everywhere a free and fair field to all with special governmental favor to none.

Mr. O'Donnell Takes Optimistic View

Thomas A. O'Donnell, president of the American Petroleum Institute, took an unusually cheerful view in his address, "Future Production of Petroleum." He minimized the danger of exhaustion of oil, declaring that if the economic law of supply and demand be given a free opportunity to assert itself, the petroleum available will be sufficient to meet the requirements in all parts of the world for many generations to come. There are vast areas in all parts of the world that have scarcely been "scratched." Frequently, in the past there have been predictions that the source of supply was exhausted and there never again would be sufficient oil to supply the demand, and in every instance these predictions have been wrong. Increased prices have always resulted in increased activity of the wildcatter, which in turn has resulted not only in producing sufficient oil to meet the demand, but usually in overproduction. The present shortage has not been caused by any serious exhaustion of the petroleum deposits, but by extraordinary increased consumption.

Nature has supplied a sufficient quantity to meet the requirements. It is unbelievable that so many governments have established restrictive rules and regulations, and in those countries not yet affected there is much agitation for restrictive legislation and regulation, which will be very effective in discouraging necessary activity. A return to a "free and open-door policy" by many governments of the world is the most important factor in an assured future supply. Unless this is done, there is no doubt that a serious shortage is confronting the world. In conclusion, Mr. O'Donnell said:

> I have no apprehension as to the future petroleum supply of either this country or the world at large; the danger now confronting us, which is really serious, is not caused by exhaustion, but is likely to occur through the foolishness of men in permitting restrictions caused by too much government. In addition to our known petroleum deposits and the new discoveries that are sure to be made, we have enormous shale deposits in the western part of the United States as a reserve in case of need; but a proper, active development throughout the world will produce our petroleum requirements so much cheaper than is possible by operating the shale beds, that I do not anticipate any important development in the use of shale during this generation.

A. S. M. E. Annual Meeting Is Here

The forty-first annual meeting of the American Society of Mechanical Engineers will be held from Tuesday, Dec. 7, to Friday, Dec. 10.

As transportation will be the timely keynote of the meeting, there will be addresses by prominent men who are recognized authorities in this field. Other subjects will be treated of, however, for papers are to be read on fuels, forest products, machine-shop work, management, railroads, design, research, textiles and power. The detailed program follows:

Monday Morning, Dec. 6—Conference of local sections' delegates; meeting of committee on power test code.

Tuesday Afternoon (simultaneous sessions)—Fuel Section: "Fuel Supply of the World," L. P. Breckenridge; "Low-Temperature Distillation of Coal," O. P. Hood; "Fuel Conservation: The Need for a Definite Policy and Its Requirements," D. M. Myers; "Form Value of Energy in Relation to Its Production, Transportation and Application," Chester G. Gilbert and Joseph E. Pogue. Forest Products: "A Photographic Study of the Wood-working Industry," F. F. Murray; "Engineering in Furniture Factories," B. A. Parks; "Use of Wood in Freight-Car Construction," H. S. Sackett; "Machining Railroad Cross-Ties," D. W. Edwards; "Creosoted Wood-Block Factory Floors," L. T. Ericson; "Processes and Equipment Used in Wood Preservation," E. S. Park and J. M. Weber; "Electrically Driven Sawmills," A. E. Hall. Machine-Shop Section: "Side-Cutting of Thread-Milling Hobs," Earl Buckingham; "Cylindrical Grinding in 1920," W. H. Chapman; "Mechanical Engraving and Die-Sinking," J. F. Keller.

Tuesday Evening—Report of tellers of election and introduction of president-elect; presidential address; conferring of six honorary memberships; presidential reception and dance.

Wednesday Morning—Business meeting: Amendments to the constitution, reports of standing committees, committee on code of ethics, industrial relations, education, feed-water-heater standardization, subcommittee on bearing metals.

Wednesday Afternoon (simultaneous sessions) — Management Section: "Mr. Gantt's Contribution to Industry," Fred J. Miller; "Mr. Gantt's Contribution to Shipbuilding, Ship Operation, Ordnance and Aircraft," Marshall Evans; "Life Work of H. L. Gantt," E. A. Lucey; "H. L. Gantt," J. F. Butterworth; "Principles of Industrial Philosophy," W. N. Polakov. Railroad Section: "Static Adjustment of Trucks on Curves," R. Eksergian; "Increasing Capacity of Old Locomotives," C. B. Smith; "Modernizing Locomotive Terminals," George W. Rink. Design—I: "Rational Design of Hoisting Drums," E. O. Waters; "Tests on Rear-Axle Worm Drives for Trucks," K. Heindlhofer; "Foundations for Machinery," N. W. Akimoff. Research—I: "Calibration of Nozzles for the Measurement of Air Flowing Into a Vacuum," W. L. de Baufre; "The Heat-Insulating Properties of Cork and Lith Board," A. A. Potter, J. P. Calderwood, A. S. Mack and L. S. Hobbs; "The Constitution and Properties of Boiler Tubes," A. E. White. Meeting of committee of standardization of plain limit gages.

Wednesday Evening—Brashear Memorial: Oration on the life and work of the late Dr. John A. Brashear, past-president, A. S. M. E., will be delivered by Dr. Henry S. Pritchett, president of the Carnegie Foundation for the Advancement of Teaching.

Thursday Morning—Keynote session on transportation: "Railroads," Daniel E. Willard, president Baltimore & Ohio R.R.; "Railroad Feeders," Charles A. Morse, chief engineer, Chicago, Rock Island & Pacific R.R.; "Waterways," General Frank T. Hines; "Motor-Truck Transportation," Francis W. Davis, engineer, Pierce-Arrow Motor Car Co. Meeting of committee on standardization of shafting.

Thursday Afternoon — Keynote session (continued): "Terminals," Colonel William Barclay Parsons, consulting engineer, of New York City; "The New York Terminal Problem," Gustav Lindenthal, consulting engineer, of New York City. Professional session, Research—II: "Effect of Fittings on Flow of Fluids Through Pipe Lines," D. E. Foster; "Steam Formulas," R. C. H. Heck. Organization meeting of the Ordnance Section: Ladies' tea and dance.

Friday Morning (simultaneous sessions) — Design—II: "Experiences with Large Center-Crank Shafts," Louis Illmer; "Design of Flywheels for Reciprocating Machinery Connected to Synchronous Generators and Motors," R. E. Doherty and R. F. Franklin. General session: "The Armor-Plate and Gun-Forging Plant of the U. S. Navy at S. Charleston, W. Va.," Roger M. Freeman; "Principles of the Gyro-Compass," George B. Crouse. Textile Section: "Textile Dye Houses," A. W. Benoit; "Power Applications to Cotton Finishing Plants," Leo Loeb; "Textile Fabrics for Mechanical Purposes," J. W. Cox. Power Section: The subject of the session will be "Future Power Development." Papers will be presented on: "The Policy of Future Power Development," "Effect of Load Factors on Cost," "Effect of Size of Plant on Cost," "Financial and Legal Aspects of Future Power Development."

Bureau of Welding Reorganized

The American Bureau of Welding was reorganized at a meeting held in the Engineering Societies Building on Nov. 22, as a joint advisory board of the Division of Engineering of the National Research Council and the American Welding Society, with the purpose of promoting welding research and standardization.

This advisory board, or bureau, is made up of representatives from the American Welding Society, other interested engineering and scientific societies and organizations, Government departments, and certain members at large selected because of their special fitness and ability in welding matters.

At the first meeting of the bureau, by-laws were adopted and the following officers elected: Director, C. A. Adams; first vice-director, H. M. Hobart; second vice-director, A. S. Kinsey; secretary, W. Spraragen.

The bureau voted to create the following research committees to advance welding research and standardization: Electric Arc Welding, Gas Welding, Training of Operators, Welding Wire Specifications, Welding Conference Committee, Specifications of Steel To Be Welded, Thermit Welding, Resistance Welding.

Water-Power Applications

Applications for water-power permits, or licenses, were received by the Federal Power Commission during the week ended Nov. 20, as follows:

Garland Hydro-Electric Power Co., 113 Fulk Building, Little Rock, Ark.; Ouachita River, Garland County, Ark.; use, public utility.

Frank G. Baum, 1901 Hobart Building, San Francisco; Little Colorado River at Grand Falls, Ariz.; use not stated.

Frank G. Baum, 1901 Hobart Building, San Francisco, Black River, Ariz.; use not stated.

W. H. Shrader, 21 East Gonzalez St., Pensacola, Fla.; U. S. dam on Sunflower River, Washington County, Miss.; use not stated.

R. L. Weeks, U. S. Army Recruiting station, 4th and Main Sts., Los Angeles; Shrimp Bay, Tongas National Forest, Alaska; use, power for pulp mill.

Alaskan-American Paper Corporation, 23 East 26th St., New York City; Orchard Lake outlet to Shrimp Bay, Tongas National Forest, Alaska; use, power for pulp mill.

The New Zealand Government is still assisting private interests in prospecting for petroleum in this dominion, and has subsidized a company that has put down a bore near Hawkes Bay to the depth of 3,660 ft. It is proposed to go much deeper, for the indications are that oil may be found in that locality. During 1919 the New Zealand government paid $21,656 in subsidies for prospecting work and will expend more this year.

The Bolivian government has been for some time contemplating the electrification of all railways and has declared as public domain the waters of such rivers as are capable of being used for the development of power. The Jafe de la Seccion de Ferrocarriles del Ministerio de Fomento has charge of these projects.

Fuels of the Future

That either oil or gas is to be the ultimate fuel was the prediction of S. W. Parr, professor of applied chemistry at the University of Illinois, in an address before the Gas Engineering Section of the Western Society of Engineers recently. Mr. Parr said that the whole question of fuel nowadays is going through a transition state. The world is demanding a fuel that has the property of mobility, that can easily be conveyed to the spot where it is wanted. This demand is to a large extent due to the development of the automobile. For steam generation there has been increasing use of liquid fuel, particularly on seagoing vessels, where all the advantages are with a fuel in liquid form. A ship the size of the "Mauretania" requires about 200 stokers when burning coal, while with oil fuel only 17 men are needed. There are other advantages, such as less storage space and greater steaming radius, so that it is evident that oil fuel is here to stay.

As the country is now using more gasoline than it is able to make, the question arises, Where will the greater supply that will be needed come from? This is a task for the chemist to determine. Of the annual yield of petroleum, approximating 350,000,000 bbl., only 12 per cent is now made into gasoline. Increasing this percentage is the big task of the chemist, and even a small gain of 2 or 3 per cent would mean a large increase in the total output. It was the speaker's belief that the chemist would succeed in increasing the yield of gasoline and that the liquid fuel of the future would be a mixture with gasoline as the base.

As to alcohol the potential yield is almost without limit. It has less heat value per pound than gasoline, but burns more completely, so that the relative merits stand in the ratio of approximately five to four in favor of gasoline. Used alone it is not a good fuel for internal-combustion engines, but gives excellent service when mixed with ether or other volatile fuel.

Although the use of gas has formerly been for lighting, its ultimate use will be principally that of a fuel. The most judicious thing to do with coal is to convert it into gas or gas and coke; it should not be burned raw. Siemmens made this statement years ago, and the truth of it is now being realized. The time is rapidly approaching when gas will begin to take the place of solid fuel for numerous purposes where it has been thought only solid fuel could be used. In the gas industry the sum total of development for the last hundred years has been in the mechanical field. The chemist is now entering the field, and many changes are to be expected. The gas produced averages about 550 B.t.u. per cu.ft., as compared to 800 B.t.u. for the gas coming directly from the coal, before the secondary reaction has taken place. It is the chemist's work to retain the higher heat value.

The University of Illinois has been interested in establishing a laboratory where investigations could be made on the manufacture of gas and the complete utilization of coal. Since 1902 they have been interested in the question as to whether it is possible to take smoke out of Illinois coal, and they are now of the opinion that it is possible to make smokeless fuel from this coal. During the process 25 to 30 gal. of liquid fuel is obtained, approximately one-half barrel per ton of coal. The gas is of the high-grade variety and averages about 750 B.t.u. per cu.ft., while the residue, coke, may be used as smokeless fuel. Burning coke, however, to generate electrical energy results in an efficiency of only 10 to 12 per cent. With the same fuel converted into gas an efficiency of 30 per cent is quite feasible, so that there is a wide margin to work upon. The better proposition, then, is to make the coke into water gas, thus converting all the coal into liquid or gaseous fuel and not burning any of it in the solid state.

Samples of coke from Illinois and West Virginia coals were presented for inspection, and it was scarcely possible to tell from which coal the coke originated. As a material for the manufacture of water gas coke from Illinois coal was considered ideal. It gives a gas containing approximately 500 B.t.u., and if the richer gas from the earlier distillation is turned into it an excellent gas of about 750 B.t.u. per cu.ft. is obtained. There are great opportunities to develop fuels of the liquid or gaseous type, using the proper chemical combinations and seeing that none of the heat is dissipated before the gas is delivered for use.

Discussion turned to the quality of coke from Illinois coal and its adaptability for blast furnace and domestic use. For the former purpose the coke should contain about 4 per cent volatile, but when burned in the home it gives better results with 10 per cent volatile. There is little doubt that coke from Illinois coal would stand up in the blast furnace. Whether all of this gas should be made at the mouth of the mine and transmitted to the point of use or whether the coal should be transported to the place where the gas is required was a question raised, and there was considerable discussion upon the use of alcohol and its production from sugar cane, potatoes containing an unusual quantity of starch, corn and other vegetable products.

The Old Hickory Powder Plant at Jacksonville, Tenn., has been sold by the United States Government to the Nashville Industrial Corporation, which is composed of business men of Nashville. Old Hickory was the largest Government manufacturing undertaking of the war; its total cost was over $87,000,000. It occupies 5,100 acres of land, has a water-filtration system capable of supplying a city the size of Boston, one of the largest steam-power plants in the world, a double-track railroad connecting with trunk lines, 35 miles of industrial track connecting manufacturing buildings, an immense refrigeration system, complete waterworks, sewerage system, fire departments and concrete and macadam roads. The village had a population of 35,000 when the plant was closed in 1918, and is now completely equipped with all necessary public utilities, schools, banks and clubhouses. The purpose of the Nashville people is to develop this war project into a large manufacturing center, having available immense housing and manufacturing buildings and facilities.

New Publications

A COURSE IN ELECTRICAL ENGINEERING, VOL. 1. By Chester L. Dawes, S.B. Published by McGraw-Hill Book Co., Inc., New York, 1920. Cloth; 5½ x 8 in.; 496 pages; 364 illustrations. Price, $4.

This is Volume 1 of two to be used as a text on electrical engineering and deals with direct current. The work begins with the most elementary conception of magnetism and the flow of current and advances to a discussion of the many types of direct-current machinery. This book and its forthcoming companion volume are intended as a stepping stone to the more advanced works on electrical engineering. In preparation of the material the needs of students taking industrial courses in electrical engineering have been carefully considered, and as a result a liberal use of illustration and illustrative problems has been made, also frequent discussions of the methods of making measurements in laboratory tests are included. Like all textbooks on the subject mathematics is used freely. However, this treatment has been limited to simple arithmetic and elementary algebra. Wherever possible an attempt has been made to apply the theory to the solution of practical problems.

Although the book is intended as a text for use in classrooms, the treatment is such as to be easily mastered by the home student. In this respect the value of the work would be considerably enhanced if the answers had been given to the several hundred electrical problems included in the work.

LESSONS IN HEAT. By Franklin and MacNutt. Published by Franklin & Charles, Bethlehem, Pa. 144 pages; 41 illustrations. Price, $2.

This volume, which was prepared for use as a college textbook, has many features to commend it, especially the explanation of the Second Law of Thermodynamics. This is usually a stumbling block to the student. In most instances a college textbook is of little worth to those whose mathematical training has been limited. In the volume under discussion the treatment is so simple that it should be of benefit to all who wish to gain a fair understanding of heat.

Obituary

William Krouse, chief engineer of the Paterson Parchment Co. for more than thirty-six years, died Nov. 20, at his home in Clinton, N. J. He was one of the early members of the National Association of Stationary Engineers, served as its state president for New Jersey, and is known to many members of the craft all over the country through his attendance at the national conventions.

Personals

J. Grady Rollow has resigned his position with E. I. duPont de Nemours & Co., and is now consulting engineer with the Los Angeles Gas and Electric Corporation.

C. C. Lance, formerly shop engineer for the Seaboard Air Line Railway Co., is now with the National Boiler Washing Co., Chicago, Ill.

A. H. Berchen has left the A. S. Cameron Steam Pump Works, of New York City, to accept a position with the Charles F. Ames Co. Ltd., 90 West St., as sales manager in this vicinity.

Lucien Buck, who was general manager of the Parana Paper Co., Inc., Parana, Brazil, S. A., has returned to the States and is now with the B. F. Sturtevant Co., Boston, Mass.

E. H. Whitney has recently joined forces with the Westinghouse Lamp Co. as district illuminating engineer of its New England office at Boston, Mass.

Dean L. A. Scipio, formerly of Robert College, of Constantinople, is now acting director of the Research Bureau of the American Society of Heating and Ventilating Engineers, in place of the late Professor Allen, with whom he had been associated.

Victor J. Azbee, consulting engineer, of St. Louis, is establishing a laboratory which will be equipped for chemical analysis and physical tests having to do with power-plant economy. It will enable him to test solid, liquid and gaseous fuels, boiler-feed water, boiler scale, etc.

S. S. Garrett has recently been advanced from the position of assistant professor in Cornell University to that of professor of mechanical engineering, having received one of the eight professionships recently established in memory of the university's students who gave their lives in the World War.

Fritz J. Frank, vice president of the Iron Age Publishing Co., has been elected president of that company, following the resignation of William H. Taylor, who had been president and general manager for more than ten years. Mr. Taylor resigned because of ill health and has retired from active connection with the company. He was for a time vice president of the McGraw Publishing Co., and, later, president of the Taylor Publishing Co., of Chicago, which consolidated the "Engineer" and "Steam Engineering." Mr. Frank has been with the Iron Age Publishing Co. since 1916, after an active association with other trade publications, among them *Colliery Engineer* and the *Mining and Scientific Press*.

Society Affairs

The American Society of Refrigerating Engineers is holding its sixteenth annual meeting at the Hotel Astor, New York City, on Dec. 6, 7 and 8. The program is given in full on another page.

The American Society of Mechanical Engineers will hold its forty-first annual meeting in the Engineering Societies Building, New York City, from Dec. 7 to 10. The full program is given on another page.

The Chicago Section of the Association of Iron and Steel Electrical Engineers will hear an address on Dec. 11 on "Switching Equipment for Steel Mill Power Houses and Sub-Stations," by J. P. Wilson, switchboard engineer with the Westinghouse Electric and Manufacturing Co.

Columbus Section, A. S. M. E., will meet on Dec. 10. Dean E. A. Hitchcock, of the Engineering College, Ohio State University, will speak on "Emergency Work in Power Plant Operation." Motion pictures will be shown of the manufacture of A. M. Byers genuine wrought-iron pipe.

The Cleveland Section of the Association of Iron and Steel Electrical Engineers will meet on Dec. 13 to hear an address by L. M. Adams, electrical engineer with the General Electric Co., on the subject of "Continuous Rated or 50 Degree Rise Motors." The meeting will be preceded by an informal dinner at 6:30 p.m.

The Philadelphia Section of the A. S. M. E. will hold a joint meeting with the A. I. E. E. and the Engineer's Club of Philadelphia on Dec. 13 in the Bellevue-Stratford Hotel. W. S. Murray will speak on "The Super-Power Survey." The meeting will be at 8 o'clock, and will be preceded by an informal dinner at 6:30.

The National Association of Practical Refrigerating Engineers will hold its annual convention at Chicago on Dec. 13, 14, 15 and 16, four days later than was originally planned. Arrangements are being made by the Chicago Subordinate. Papers will be presented by prominent men in the refrigerating industry; the program will be entirely educational and will amount, in fact, to an intensive course of instruction. All refrigerating engineers, whether members or not, are invited to attend.

Business Items

The Hagan Corporation has expanded its New York City organization, and has taken new offices at 110 West 34th St.

The Philadelphia Belting Co. announces that its New York Office is now under the management of Harry F. Wooden, a transmission engineer and packing expert. Problems of a technical character are solicited.

The Illinois Stoker Co., Alton, Ill., manufacturer of forced and natural draft chain-grate stokers, announces the appointment of the Ernest E. Lee Co. as district representatives for Iowa, Wisconsin, Michigan, Northern Indiana, and Northern Illinois with offices at 115 South Dearborn St., Chicago.

Trade Catalogs

Gillis & Geoghegan, 529 West Broadway, New York City, have just issued a booklet showing the labor-saving uses of G. & G. Hoists in factory buildings. Special prominence has been given a new electric model which consumes only half the amount of current that the former one used. Installations in machine shops, automotive buildings, chemical plants, railroad and other shops are shown.

The Graton & Knight Manufacturing Co., Worcester, Mass., has put out a new 96-page, 5 x 8-in. catalog on "Standardized Leather Belting for Power Transmission." The book is attractively bound and contains not only specifications of the company's product, but also some very handy and practical information on belt problems, which should be of value to millwrights and others having to do with belts.

COAL PRICES

Bituminous—The following table shows the trend of the spot steam market in various coals (mine-run basis, f.o.b. mines):

	Nov., 1919*	Aug. 5, 1920	Dec. 2, 1920†
Pittsburgh steam	$2.30	$10.00	**$5.00**
Pittsburgh gas	2.30	12.00	*5.50*
Hocking	2.50	9.00	**4.50**
Franklin, Ill.	2.35	6.50	**5.00**
Indiana 4th vein	2.35	7.50	*4.00*
Eastern Ohio, No. 8	2.35	10.50	**5.00**
Fairmont	2.50	13.50	**4.75**
Kanawha	2.60	14.00	**4.75**
S. E. Kentucky	3.00	10.50	**5.25**
Western Kentucky	2.35	5.25	**4.25**
Clearfield	2.95	12.00	**5.00**
Cambria and Somerset	2.95	13.50	**6.00**
New River	2.70	14.00	**5.25**
Pocahontas	2.35		

* Government prices.

† Advances over the previous week shown in **heavy type**, declines in *italics*.

New Construction

PROPOSED WORK

Mass., Boston—The Schoolhouse Dept. will soon receive bids for a 4 story, 220 x 250 ft. Latin school including a steam heating system on Louis Pasteur Ave. About $1,000,000. J. E. McLaughlin, 88 Tremont St., Archt.

Mass., Roxbury (Boston P. O.)—The Children's Hospital, 300 Longwood Ave., plans to build a 3 story nurses' home including a steam heating system. About $600,000. Coolidge & Shattuck, 122 Ames Bldg., Boston, Archts.

Mass., Worcester—The Holy Cross College will soon award the contract for a 49 x 100 ft. chapel including a steam heating system. About $300,000. Rev. J. J. Carlin, Pres. Sheehan & Colleary, 120 Boylston St., Boston, Archts.

Conn., New Haven—The United Illuminating Co., 84 Temple St., had plans prepared for a 40 x 60 ft. plant extension on Grand Ave. Westcott & Mapes, Inc., 207 Orange St., Archts. and Engrs.

Conn., Storrs (Eagleville P. O.—The Connecticut Agricultural College, c/o Building Com., will receive bids until Dec. 14 for a 3 story, 110 x 186 x 53 ft. dormitory including a steam heating system. About $335,000. D. K. Perry, 27 West Main St., Archt.

Conn., Waterbury—The Connecticut Military Emergency Bd., State Armory, Hartford, will select new architect and receive bids soon for a 4 story armory including a steam heating system on Field St. About $400,000. Noted July 27.

Conn., West Haven—The Union School Dist., Orange, will receive bids early in January for a 3 story high school here, including a steam heating plant. Cost, between $350,000 and $400,000. R. W. Foote, 185 Church St., New Haven, Archt.

N. Y., New York—Marc Klaw, Inc., 1451 B'way, had sketches prepared for 2 theaters including a steam heating system at 46th St. near 8th Ave. About $650,000. DeRosa & Pereira, 110 West 40th St., Archts. and Engrs.

N. Y., New York—The Society for Prevention of Cruelty to Children, 83 Irving Place, had sketches prepared for an institution including a steam heating system on 5th Ave. About $3,000,000. Maynicke & Franke, 25 East 26th St., Archts. and Engrs.

N. Y., New York—Figge & Hutwelker, 627 West 40th St., are having plans prepared for a tank house including a steam heating system. About $500,000. Henshein & McLaren, 37 West Van Buren St., Chicago, Ill., Archts.

N. Y., New York—The Bowery Savings Bank, Bowery and Grand St., plans to build a 20 story, 105 x 200 ft. bank and office building including a steam heating system on 42d St. Archt. and Engr. not selected.

N. Y., Ossining—Chas. S. Ratigan, Supt. of Prisons, received bids for the installation of a heating system for additional accommodations at Sing Sing Prison from A. B. Barr & Co., 6 River St., Yonkers, $21,500; Globe Heating Co., 209 Washington Ave., Philadelphia, Pa., $22,150; Miller & Brady, 210 East 38th St., New York City, $23,760.

N. Y., Rochester—The Chocolate Shoppe, 11½ North Clinton Ave., is in the market for a 12-in. a.c., 110-volt blower. A. Callis, Pur. Agt.

Pa., Philadelphia—The Bd. Educ., 19th and Chestnut Sts., had plans prepared for a 3 story, 145 x 170 ft. school including a steam heating system on 7th and Norris Sts.

Md., Baltimore—The Immaculate Conception R. C. Church plans to build a church, school, rectory and sisters' house at Liberty Heights Ave. and Hilton St. About $500,000. Rev. G. V. McKinney, 532 Mosher St., Pastor. F. Baldwin, 328 North Charles St., Archt.

Md., Baltimore—The Duraflex Co., 409 Continental Bldg., is in the market for a 50 hp. boiler and 35 to 50 hp. motors. J. F. Nachod, Gen. Mgr.

D. C., Washington—The Catholic University, Brookland, here, is having plans prepared for a 100 x 600 ft. church at the university grounds. About $5.000,000. Maginnis & Walsh, 100 Boylston St., Boston, Mass., Archts.

N. C., Canton—The Champion Fiber Co. plans to build a 140 ft. paper mill and a 92 x 400 ft. board mill. About $750,000.

N. C., Kinston—The city will soon award the contract for power plant and pumping station buildings. W. C. Olsen, Engr. Noted Nov. 30.

N. C., Raleigh—The Raleigh Ice & Cold Storage Co, c/o J. L. Dorminy, plans to build a wholesale ice-manufacturing plant and cold storage house to be electrically operated, on West Hargett St. About $100,000. Archt. and Engr. not selected.

Fla., Tampa—C. H. Brown, 510½ Franklin St. and F. Hensley plan to build a 90 x 105 ft., 12 to 15 story, office building. Archt. not selected.

O., Cleveland—The Cleveland Bar Assn., c/o J. J. Sullivan, Williamson Bldg., plans to build a 12 story office building including a steam heating system. About $1,500,000. Archt. not selected.

O., Lakewood (Cleveland P. O.)—The Bd. Educ., G. W. Grill, Clk., Warren Rd., will receive bids until Dec. 13 for a 3 story, 82 x 144 ft. high school including a steam heating system on Jackson Ave. About $350,000. C. W. Hopkinson, Rose Bldg., Cleveland, Archt.

O., Lorain—The Bd. Educ., East 6th St. and Washington Ave., is having plans prepared for a 2 story high school including a steam heating system at East 20th St. and Oakdale Ave. About $350,000. F. C. Warren, Hippodrome Annex Bldg., Cleveland, Archt.

O., Marietta—The Peoples' Banking & Trust Co. will receive bids until Jan. 1 for an 11 story, 51 x 114 ft. bank and office building including a high pressure steam heating plant. Weary & Alford, 1732 South Michigan Blvd., Chicago, Ill., Archts.

Ind., Linton—The city is having plans prepared for a 70 x 100 ft. light plant and will soon award the contract for equipment. About $100,000. Shrouds Stoner Co., Tribune Bldg., Terre Haute, Archts.

Ind., Richmond—W. Stevens, City Clk., will receive bids until Dec. 15 for a 75 x 85 ft. light plant and the contract will soon be awarded for equipment. J. D. Lyon, 2513 Union Central Bldg., Cincinnati, Ohio, Engr.

Ind., Thorntown—The Bd. Educ. will purchase two smokeless fire-box boilers, vacuum pumps, etc.

Ind., Wabash—The Wabash National Bank will receive bids until Dec. 15 for a bank building including a steam heating system. About $250,000. Weary & Alford, 1732 South Michigan Blvd., Chicago, Ill., Archts.

Mich., Benton Harbor—The Washington Hotel & Mineral Baths plans to build a 3 story, 200 x 300 ft. hotel including a steam heating system. Bennett & Gibb, 117 North Dearborn St., Chicago, Ill., Archts.

Mich., Detroit—The Zenith Foundry Co., Miller Ave., will receive bids until Dec. 10, for a 1 story, 90 x 200 ft. foundry including electric motors for power. G. W. Grave, 43 John R. St., Archt.

Mich., Detroit—The Bd. Educ., 50 B'way Ave., will receive bids until Dec. 21 for a 5 and 7 story, 250 x 350 ft. addition to the technical high school at Second Ave. and High St., including a gas engine laboratory. Steam heating and power equipment will also be required. Malcolmson, Higginbotham & Palmer, 405 Moffat Bldg., Archts.

Mich., Flint—St. Michael's Parish plans to build a 3 story parochial school including a steam heating plant. About $500,000. Archt. not selected.

Mich., Monroe—The Dansard State Bank will receive bids about Jan. 15 for a bank building including a steam heating system. About $250,000. Weary & Alford, 1732 South Michigan Blvd., Chicago Ill., Archts.

Mich., Muskeegan—The National Lumbermans' Bank, 13 West Western Ave., will receive bids until Jan. 15 for a bank and office building including a steam heating system. About $300,000. Weary & Alford, 1732 South Michigan Blvd., Chicago, Ill., Archts.

Ill., Chicago—The Woodlawn Trust & Saving Bank, c/o Weary & Alford, 1732 South Michigan Blvd., will receive bids until Dec. 15 for a bank and office building including a steam heating system. About $400,000.

Ill., Chicago—The Illinois Malleable Co., 1801 Diversey Blvd., plans to install a 12-panel electric switchboard. Cahill & Douglas, 217 West Water St., Milwaukee, Engrs.

Ill., Hanover—The village clerk will receive bids about February 1 for a waterworks system including a pump house, pump, etc. About $25,000. Holland, Ackerman & Holland, Ann Arbor, Mich., Engrs.

Wis., Albany—W. G. Kirchoffer, Engr., 31 Vroman Block, Madison, received no bids for centrifugal pump, motor and controlling apparatus for waterworks plant. Noted Nov. 9.

Wis., Helenville—The Blochowiat Dairy Co., 1364 4th Ave., Milwaukee, has selected a site for a 2 story, 80 x 140 ft. dairy products factory on Main St, here. About $75,000. Archt. not selected.

Wis., Manitowoc—The Manitowoc Hotel Realty Co. plans to build an addition to hotel at 825 8th St., S. About $500,000. H. B. Hamschulte, North 8th St., Archt. W. C. Loeggering, c/o Forest Avenue Hotel, 170 Forest Ave., Fond du Lac, is interested.

Wis., Milwaukee—The Milwaukee Reliance Boiler Co., 1102 32d St., had preliminary plans prepared for a 1 story, 100 x 125 ft. boiler shop addition. A. D. Koch, Wells Bldg., Archt.

Wis., Milwaukee—The Milwaukee Children's Hospital, 219 10th St., had preliminary plans prepared for a hospital and power plant on Grand Ave. About $450,000. Scott & Mayer, Colby-Abbot Bldg., Archts. and Engrs.

Wis., Park Falls—The city plans to extend the water mains about 2 miles and will require pumping equipment. About $50,000.

Wis., Racine—The Grant Furniture Co., 502 6th St., is having plans prepared for a 3 story, 80 x 120 ft. factory on Washington Ave. Electric motors will be installed in same. D. R. Davis, Schultz Bldg., Archt. and Engr.

Wis., Superior—W. J. Little, Secy of the Bd. of Normal School Regents, will receive bids about Jan. 2 for a 2 story, 150 x 265 ft. gymnasium including a steam heating system. About $300,000. Archt. and Engr. not selected.

Wis., Wausau—The American Nat'l Bank, 502 3d St., plans to build a bank and office building including a steam heating system. About $300,000. C. S. Gilbert, Pres. Archt. not selected.

Wis., West Allis—The city plans improvements to the water supply plant including a reservoir near Woodlawn and Lincoln Aves., and a new pumping station to be equipped with 2 electrically-driven pumps of a 2,500,000 gal. daily capacity.

Ia., Rheinbeck—The Bd. Educ. plans to build a 2 story, 90 x 144 ft. high school and install boilers, pump, etc. About $225,000. Nitcotts & Nitcotts, 516-19 Black Bldg., Waterloo, Archts.

Minn., Mankato—The Immanuel Hospital Assn. plans to build a 2 or 3 story addition to hospital including a central heating plant. About $150,000. Rev. A. F. Winter, Chn. of plan committee. Archt. not announced.

Minn., Minneapolis—The Radison Hotel Co. plans to build an addition to hotel on 7th St. between Nicollet and Hennepin Aves. About $1,800,000. S. Kraus, Pres. Archt. not announced.

S. D., Tyndall—The city has made arrangements for the issue of $50,000 bonds to be used for a municipal light, heat and power plant.

Okla., Nowata—The Gunther City Coke & Coal Mining Co. is interested in an electric light plant. C. B. Circles, Pur. Agt.

Tex., Halletsville—The city plans an election Dec. 12 to vote on $20,000 bonds for the purchase and installation of a new steam engine for the electric light plant.

Col., Denver—The Simm Finance Co. has leased a site at East 17th Ave. and Broadway to an organization for a 6 story, 125 x 150 ft. physicians' building, also a 2 story garage and filling station. About $1,000,000. W. N. Bowman Co., Central Savings Bank Bldg., Archt.

Utah, Fillmore—The Telluride Power Co., 415 Walker Bank Bldg., Salt Lake City, plans to extend its power line for pumping purposes, through the artesian well belt, McCormick, Delta and other nearby towns.

Utah, Provo—F. W. C. Hathenbruck has filed application with the state engineer for permission to divert water from the subsoil flow in Slate canyon to operate a 300-hp. hydro-electric plant for mining purposes.

Que., St. Laurent—The Canada Heaters Co., Ltd., plans to build a 1 story plant. About $250,000.

Ont., Belleville—The Albert College plans to build a 3 story college including a vacuum steam heating system. About $500,000. Chapman, Oxley & Bishop, Harbor Bldg., Toronto, Archts.

Ont., Brantford—The Lake Erie & Northern Power Plant, recently destroyed by fire, will be rebuilt and equipment purchased at a cost of $110,000.

Ont., Brockville—The Lanig Produce & Storage Co., Water St., E., plans to build an addition to the present plant. About $400,000. J. G. Gardner, Pres. Archt. not selected.

Ont., Richmond Hill—The city plans to establish a complete waterworks system including a pump house, reservoir, electrically driven centrifugal pumps, etc About $95,000. E. A. James Co., 36 Toronto St., Toronto, Engr.

Ont., Shelburne—The town plans to extend the existing waterworks including new pump house, installation of three-stage, 1,000 g.p.m. electrically driven centrifugal pumps, etc. About $100,000. E. A. James Co., 36 Toronto St., Toronto, Engrs.

Ont., Toronto—The Toronto Skating Club, c/o Lt.-Col. A. E. Kirkpatrick, Excelsior Life Bldg., has purchased site and plans to build a 1 story skating rink including steam heating system in clubhouse portion. Equipment for the manufacture and maintenance of an artificial ice surface will be installed.

Cuba, Havana—M. Diaz is having plans prepared for a bottling plant including a steam heating system. About $1,000,000. Ophuls, Hill & McCreery, 112 West 42d St., New York City, Archts. and Engrs.

CONTRACTS AWARDED

S. C., Summerville—J. F. Prettiman & Sons, has awarded the contract for a 32 x 68 ft. power house to H. K. Ferguson Co., Vickers Bldg., Cleveland, Ohio, at $25,000.

O., Cincinnati—B. F. Keith, c/o Rapp & Rapp, 190 North State St., Chicago, Ill., has awarded the contract for a 12 story, 123 x 200 ft. theater and office building, here, including a high pressure steam heating system, to Ohio Bldg. & Constr. Co., Burnet St., at $1,250,000.

O., Cleveland—St. Hyacinth's Catholic Church, 2965 East 75th St., has awarded the contract for a 2 story, 40 x 80 ft. boiler house and garage to Law & Strauss, Builders' Exchange, at $35,000. Noted Oct. 5.

O., Cleveland—The Cleveland Heater Co., 1540 West 112th St., has awarded the contract for a 40 x 50 ft. boiler house addition to the H. K. Ferguson Co., Vickers Bldg., at $20,000.

O., Lima—The Crystal Ice & Coal Co. has awarded the contract for a 1 story ice plant to be electrically operated, to the Triumph Ice Machine Co., Cincinnati, at $25,000.

Mich., Buchanan—The city has awarded the contract for furnishing 3 centrifugal pumps, motors, etc., to the Manistee Iron Wks., Manistee.

Mich., Detroit—Julius Stroh, 1676 Jefferson Ave., has awarded the contract for an 18 story, 80 x 100 ft. office building including a high pressure steam plant to the Lanquist & Illsley Co., 1100 North Clark St., Chicago, Ill., at $1,200,000.

Mich., Oxford—The city has awarded the contract for improvements to the waterworks system to the Gang Constr. Co., 737 Second Nat'l. Bldg., Akron, Ohio, at $29,000. Noted Nov. 2.

Wis., Granville—The T. J. Moss Tie Co., Security Bldg., St. Louis, Mo., has awarded the contract for a creosoting plant here, including three buildings and a 30 x 40 ft. boiler house to J. L. Strange, 144 Oneida St., Milwaukee.

Wis., Marshfield—The city has awarded the contract for a 1 story, 36 x 40 ft. addition to the power house to Krasin Bros., at $20,000. Noted Nov. 16.

Wis., Milwaukee—The Shope Brick Co., 49th and State Sts., has awarded the contract for a 25 x 47 ft. boiler house to the American Contg. Co., 198 Milwaukee St., and for one 150-hp. boiler for heating system to J. S. Jung, 1010 Greenfield Ave.

Minn., Cloquet—The North West Paper Co., East End, has awarded the contract for work on dam to Siems, Helmers & Schaffner, 514 Guardian Life Bldg., St. Paul.

Kan., Liberal—The city has awarded the contract for furnishing a deep well centrifugal pump to the American Well Wks., 319 Reliance Bldg., Kansas City, Mo., at $20,300.

N. D., Ashley—McIntosh County has awarded the contract for furnishing a 20-hp. engine, one fuel tank, one 12½ kw. generator, 125-volt, d.c. to engine, one 112 1/1 amp. hour Edison storage battery and one switchboard, for the court house, to Fairbanks & Co., 111 West Washington St., Chicago, Ill., at $5,225.

Col., Wellington—The DuPont Sugar Co., 627 19th St., Denver, has awarded the contract for a sugar factory, here, to the Schwartz Engineering Co., 310 Mack Bldg., Denver, at $1,000,000.

Man., Winnipeg—The Provincial Government, Parliament Bldgs., has awarded the contract for a 2 and 3 story school for the deaf on Tuxedo Park site to Carter-Halls Co., 515 Union Bank Bldg., at $621,000. Separate bids will be taken for the heating, etc.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

POWER-PLANT SUPPLIES

HOSE—

	Fire	50-Ft. Lengths
Underwriters' 2½-in.		75c per ft.
Common, 2½-in.		40%

	Air		
	First Grade	Second Grade	Third Grade
¾-in. per ft.	$0.50	$0.35	$0.25

Steam—Discounts from List

First grade..... 20% Second grade..... 40% Third grade.... 50%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition..... 40% Best grade..... 25%
Standard..... 40-10%

LEATHER BELTING—Present discounts from list in fair quantities (½ doz. rolls):

Light Grade	Medium Grade	Heavy Grade
30%	25%	20%

RAWHIDE LACING { For cut, best grade, 25%, 2nd grade, 30%. For laces in sides, best, 79c per sq. ft.; 2nd, 75c. Semi-tanned: cut, 20%; sides, 83c per sq. ft.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam	$1.00
Asbestos for high-pressure steam	2.00
Duck and rubber for piston packing	1.20
Flax, regular	1.20
Flax, waterproofed	1.70
Compressed asbestos sheet	1.00
Wire insertion asbestos sheet	1.50
Rubber sheet	.50
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.60
Rubber sheet, cloth insertion	.50
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.50
Asbestos wick, ½- and 1-lb. balls	.85

PIPE AND BOILER COVERING—Below are part of standard lists, with discounts.

PIPE COVERING		BLOCKS AND SHEETS	
Pipe Size	Standard List Per Lin.Ft.	Thickness	Price per Sq.Ft.
1-in.	$0.27	½-in.	$0.27
2-in.	.36	1 -in.	.30
6-in.	.80	1½-in.	.45
4-in.	.60	2 -in.	.60
3-in.	.45	2½-in.	.75
8-in.	1.10	3 -in.	.90
10-in.	1.30	3½-in.	1.05

85% magnesia high pressure..... List +5%

For low-pressure heating and return lines { 4-ply..... 50% off; 3-ply..... 52% off; 2-ply..... 54% off

GREASES—Prices are as follows in the following cities in cents per pound for barrel lots:

	Cincinnati	Chicago	St. Louis	Birmingham	Denver
Cup	8½	6.6	8@ 9	8½	13½
Fiber or sponge	8½	8.6	12@15	8½	20
Transmission	10	8.1	12@15	8½	20
Axle	...	4.8	6@ 6½	5½	7½
Gear	6½	6.1	8@ 9	5½	8½
Car journal	12(gal.)	4 7	23@25	8½	8½

COTTON WASTE—The following prices are in cents per pound:

	New York			
	Current	One Year Ago	Cleveland	Chicago
White	15.00@17.00	13.00	16.00	11.00 to 14.00
Colored mixed	9.00@14.00	9.00 to 12.00	12.00	9.50 to 12.00

WIPING CLOTHS—Jobbers' price per 1000 is as follows:

	13½ x 13½	13½ x 20½
Cleveland	$55.00	$65.00
Chicago	41.00	43.50

LINSEED OIL—These prices are per gallon:

	New York		Chicago	
	Current	One Year Ago	Current	One Year Ago
Raw in barrels (5 bbl. lots)	$0.95	$2.15	$1.25	$2.37
5-gal. cans	1.10	2.30	1.50	2.57

With lower prices obtainable in New York.

WHITE AND RED LEAD—Base price per pound:

	Red				White	
	Current		1 Year Ago		Current	1 Yr. Ago
	Dry	In Oil	Dry	In Oil	Dry and In Oil	Dry and In Oil
100-lb. keg	14.25	15.75	13.00	14.50	14.25	13.00
25- and 50-lb. kegs	14.50	16.00	13.25	14.75	14.50	13.25
12½-lb. keg	14.75	16.25	13.50	15.00	14.75	13.50
1-lb. cans	17.25	18.75	15.00	16.50	17.25	15.00
5-lb. cans	19.25	20.75	16.00	17.50	19.25	16.00

500 lb. lots less 10% discount; 2000 lb. lots less 10-2½%.

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ⅞ and smaller	List net	40%	30%
Tinned	List net	40%	30%

Boiler rivets, ¾, ⅞, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.:

New York.....$6.11 Chicago.....$5.00 Pittsburgh.....$4.50

Structual rivets, same sizes:

New York.....$7.10 Chicago.....$5.10 Pittsburgh.....$4.60

REFRACTORIES—Prices in carlots:

Bauxite brick, 56% alumina, f.o.b. Pittsburgh	per 1000	$160
Chrome brick, eastern Shipping points	net ton	100@$110
Chrome cement, 40@45% Cr_2O_3	net ton	55@ 60
Chrome cement, 40@45% Cr_2O_3, in sacks	net ton	60@ 65
Clay brick, 1st quality, fire clay, 9-in. shapes, Pennsylvania, Ohio and Kentucky	per 1000	55@ 60
Clay brick, 2d quality, fire clay, 9-in. shapes Pennsylvania, Ohio and Kentucky	per 1000	45@ 50
Magnesite brick: 9-in. straight	net ton	110
Magnesite brick: 9-in. arches, wedges and keys	net ton	121
Magnesite brick: Soaps and splits	net ton	134
Silica brick: Chicago district	per 1000	65@ 70
Silica brick: Birmingham, Ala	per 1000	56@ 61
Silica brick: Mt. Union, Pa	per 1000	55@ 60

BABBITT METAL—Warehouse prices in cents per pound:

	New York		Cleveland		Chicago	
	Current	One Year Ago	Current	One Year Ago	Current	One Year Ago
Best grade	70.00	90.00	47.00	70.00	45.00	60.00
Commercial	30.00	50.50	18.00	16.50	11.00	13.00

COLD FINISHED STEEL—Warehouse prices are as follows:

	New York	Chicago	Cleveland
Round shafting or screw stock, per 100 lb. base	$5.50	$5.80	$5.50
Flats, square and hexagons, per 100 lb. base	6.00	6.00	6.00

SHEETS—Quotations are in cents per pound in various cities from warehouse, also the base quotations from mill:

	Large Mill Lots		San	New York	
Blue Annealed	Pittsburgh	Chicago	Francisco	Current	One Yr. Ago
No. 10	$3.55@$4.50	$6.13	$8.65	$6.15@$7.25	$4.82
No. 12	3.60@ 4.55	6.18	8.70	6.20@ 7.30	4.87
No. 14	3.65@ 4.60	6.23	8.75	6.25@ 7.35	4.92
No. 16	3.75@ 4.70	6.33	8.85	6.35@ 7.45	5.02
Black					
*Nos. 18 and 20	4.20@ 5.35	6.90	10.60	7.90@ 8.80	5.80
*Nos. 22 and 24	4.25@ 5.40	6.95	10.65	7.95@ 8.85	5.85
*No. 26	4.30@ 5.45	7.00	10.70	8.00@ 8.90	5.90
*No. 28	4.35@ 5.50	7.10	10.80	8.10@ 9.00	6.00
Galvanized					
No. 10	4.70@ 6.00	7.25	.....	8.65@ 9.50	6.25
No. 12	4.80@ 6.10	7.30	11.35	8.75@ 9.50	6.30
No. 14	4.80@ 6.10	7.45	11.35	8.75@ 9.60	6.35
Nos. 18 and 20	5.10@ 6.40	7.75	11.65	9.00@ 9.90	6.65
Nos. 22 and 24	5.25@ 6.55	8.15	11.80	9.15@10.05	6.80
*No. 26	5.40@ 6.70	8.30	11.95	9.30@10.20	6.95
*No. 28	5.70@ 7.00	8.60	12.25	9.60@10.50	7.25

WROUGHT PIPE—The following discounts are to jobbers for carload lots on the Pittsburgh basing card:

BUTT WELD

Steel			Iron		
Inches	Black	Galv.	Inches	Black	Galv.
¼ to 3	54 to 57½	41½ to 44	⅛	15½ to 25½	+1½ to 11
			¼	19½ to 29½	1½ to 11½
			⅜ to 1¼	24½ to 34½	8 to 18½

LAP WELD

2	47 to 50½	34½ to 38	2	20½ to 28½	6½ to 14½
2½ to 6	50 to 53½	37½ to 41	2½ to 6	22½ to 30½	9½ to 17½
7 to 12	47 to 50½	33½ to 37	7 to 12	19½ to 27½	6½ to 14½
13 and 14	37½ to 41				
15	35 to 38½				

BUTT WELD, EXTRA STRONG, PLAIN ENDS

¼ to 1¼	52 to 55½	39½ to 43	¼ to 1¼	24½ to 34½	9½ to 19½
2 to 3	53 to 56½	40½ to 44			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	45 to 48½	33½ to 37	2	21½ to 29½	8½ to 16½
2½ to 4	48 to 51½	36½ to 40	2½ to 4	23½ to 31½	11½ to 19½
4½ to 6	47 to 50½	35½ to 39	4½ to 6	22½ to 30½	10½ to 18
7 to 8	43 to 46½	29½ to 33	7 to 8	14½ to 22½	2½ to 10½
9 to 12	38 to 41½	24½ to 28	9 to 12	9½ to 17½	5½ to+2½

BOILER TUBES—The following are the prices for carload lots, f.o.b. Pittsburgh:

Lap Welded Steel		Charcoal Iron	
3½ to 4½ in.	20 to 40½	1½ to 1¾ in.	+23
2¾ to 3¼ in.	11 to 30½	2½ in.	+10 to +12
2¼ to 2½ in.	3 to 30½	2¼ in.	+1 to +10
1⅞ to 1¼ in.	+7 to −19½	2¼ and 3½ in.	−1½ to +3
		3¾, 4 and 4½ in.	−8

Standard Commercial Seamless — Cold Drawn or Hot Rolled

	Per Net Ton		Per Net Ton
1 in.	$327	1¾ in.	$207
1¼ in.	267	2 to 2½ in.	177
2¼ in.	257	2¾ to 3¾ in.	167
1½ in.	207	4 in.	187
		4½ to 5 in.	207

ELECTRICAL SUPPLIES

ARMORED CABLE—

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$85.00(net)	$138.00	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:

Less than coil lots	+ 5%	+15%
Coils to 1,000 ft.	− 5%	List Net
1,000 ft. and over	−10%	7%

BATTERIES, DRY—Regular No. 6 size red seal, Columbia, or Ever-Ready:

	Each, Net
Less than 12	$0.48
12 to 50	.41
50 to 125 (bbl.)	.38
125 (bbl.) or over	.35

CONDUIT, Price per 1000 ft.; ELBOWS AND COUPLINGS, Per 100 pieces, f. o. b. New York, with 10-day discount of 5 per cent.

Size, In.	Conduit Black 2,500 to 5,000 Lbs.	Conduit Galvanized 2,500 to 5,000 Lbs.	Elbows Black 2,500 to 5,000 Lbs.	Elbows Galvanized 2,500 to 5,000 Lbs.	Couplings Black 2,500 to 5,000 Lbs.	Couplings Galvanized 2,500 to 5,000 Lbs.
¼	85.66	90.39	20.20	21.34	6.38	6.74
⅜	113.62	119.99	26.58	27.83	7.44	7.86
½	167.96	177.38	39.35	41.56	10.63	11.23
¾	227.24	239.98	50.10	52.80	13.82	14.60
1	271.70	286.93	66.80	70.40	18.93	19.95
1¼	365.56	386.06	122.47	129.07	23.38	24.64
1½	577.98	610.39	200.41	211.21	31.18	32.85
2	755.82	798.20	534.43	563.23	44.53	46.94
2½	936.38	987.52	1,180.20	1,243.80	66.80	70.40
3	1,131.20	1,191.81	1,363.91	1,437.41	89.07	93.87
3½						
4						

CONDUIT NON-METALLIC, LOOM—

Size I. D., In.	Feet per Coil	List, Ft.
⅜	250	$0.05½
½	250	.06
⅝	250	.09
¾	200	.12
⅞	200	.15
1	150	.18
1	100	.25
1¼	100	.33
1½	Odd lengths	.40
2	Odd lengths	.55

1000 ft. and over 40%
Coils 30%
Less coils, 20%

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.12	D. P. D. B.	$0.43
D. P. M. L.	.21	T. P. to D. P. S. B.	.26
T. P. M. L.	.33	T. P. S. B.	.38
D. P. S. B.	.23	T. P. D. B.	.64

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.50	$1.30	$1.68
T. P. M. L.	.70	1.70	2.40
D. P. S. B.	.63	1.60	.....
T. P. S. B.	1.15	2.40	.....
D. P. D. B.	1.10	3.00	.....
T. P. D. B.	1.90	5.40	.....
T. P. to D. P. D. B.	1.30	3.80	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton twisted	$23.50
No. 16 cotton twisted	27.00
No. 18 cotton parallel	29.40
No. 16 cotton parallel	36.25
No. 18 cotton reinforced heavy	39.50
No. 16 cotton reinforced heavy	45.75
No. 18 cotton reinforced light	34.80
No. 16 cotton reinforced light	39.45
No. 18 cotton Canvasite cord	26.00
No. 16 cotton Canvasite cord	28.50

FUSES, ENCLOSED—

250-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.25
35-amp. to 60-amp.	100	.35
65-amp. to 100-amp.	50	.90
110-amp. to 200-amp.	25	2.00
225-amp. to 400-amp.	25	3.60
425-amp. to 600-amp.	10	5.50

600-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.40
35-amp. to 60-amp.	100	.60
65-amp. to 100-amp.	50	1.50
110-amp. to 200-amp.	25	2.50
225-amp. to 400-amp.	25	5.50
450-amp. to 600-amp.	10	8.00

Discount: Less 1-5th standard package 15%
1-5th to standard package 28%
Standard package 45%

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package	$5.25C
0-30 ampere, less than standard package	6.00C

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs Mazda B— Watts	Plain	Frosted	No. in Package	Pear-Shaped Bulbs Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.40	$0.45	100	75	$0.75	$0.80	50
15	.40	.45	100	100	1.10	1.25	24
25	.40	.45	100	150	1.55	1.70	24
40	.40	.45	100	200	2.10	2.30	24
50	.40	.45	100	300	3.15	3.40	24
60	.45	.50	100				12
				500	4.60	4.90	12
				750	6.50	6.90	8
				1,000	7.50	7.95	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.28
Composition 2-piece attachment plug	.36
Swivel attachment plug	.20
Current taps	.45

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o. b. New York.

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$ 9.00	$12.50	$16.28	$25.50
12	13.70	17.48	19.79	31.00
10	17.90	22.01	26.06	42.00
8	22.50	31.05	35.00	57.00
6	.....	.....	49.00	.....
4	.....	.....	68.00	.....
2	.....	.....	95.45	.....
1	.....	.....	140.00	.....
0	.....	.....	158.00	.....
00	.....	.....	185.50	.....
000	.....	.....	228.00	.....
0000	.....	.....	283.00	.....

Prices per 1000 ft. for Rubber-Covered Wire in Following Cities:

No.	Denver Single Braid	Denver Double Braid	Denver Duplex	Birmingham Single Braid	Birmingham Double Braid	Birmingham Duplex
14	$13.50	$16.80	$30.80	$10.81*	$13.50	$28.90
10	21.10	24.60	51.55	19.02*	24.05	49.43
8	27.60	32.35	67.60	27.84*	33.84	63.43
6	49.00	51.30	.....	50.60*	.....	.....
4	66.00	68.85	.....	89.60†	.....	.....
2	93.50	95.50	.....	118.00	.....	.....
1	128.00	131.05	.....	156.00	.....	.....
0	175.00	175.00	.....	194.00	.....	.....
00	.....	.....	.....	225.15	.....	.....
000	.....	.....	.....	256.00	.....	.....
0000	.....	.....	.....	325.00	.....	.....

* Solid; † stranded.

SOCKETS, BRASS SHELL—

¼ In. or Pendant Cap Key Each	Keyless Each	Pull Each	⅜ In. Cap Key Each	Keyless Each	Pull Each
$0.33	$0.30	$0.60	$0.39	$0.36	$0.66

Less 1-5th standard package ..... +50%
1-5th to standard package ..... +20%
Standard package ..... −15%

WIRE, ANNUNCIATOR AND DAMPPROOF OFFICE—

No. 18 B. & S. regular spools (approx. 8 lb.)	50c. lb
No. 18 B. & S. regular 1-lb. coils	51c. lb

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 56c. lb., 100 lb. lots	52c. lb
Rubber tape, ¾ in., less 100 lb. 65c. lb., 100 lb. lots	60c. lb
Wire solder, less 100 lb. 47c. lb., 100 lb. lots	42c. lb
Soldering paste, 2 oz. cans	$1.50 doz

SWITCHES, KNIFE—

TYPE "C" NOT FUSIBLE

Size, Amp.	Single Pole, Each	Double Pole, Each	Three Pole, Each	Four Pole, Each
30	$0.42	$0.68	$1.02	$1.36
60	.74	1.22	1.84	2.44
100	1.50	2.50	3.76	5.00
200	2.70	4.50	6.76	9.00

TYPE "C" FUSIBLE, TOP OR BOTTOM

30	70	1.06	1.60	2.12
60	1.18	1.80	2.70	3.60
100	2.38	3.66	5.50	7.30
200	4.40	6.76	10.14	13.50

Discounts:

Less than $10.00 list value	+25%
$10 to $25 list value	+10%
$25 to $50 list value	+ 5%
$50 to $200 list value	−10%
$200 list value or over	−15%